ADVANCED AGRICULTURE

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PREFACE

THE success attending his Elementary Text-book on Agriculture, induced the late Dr. Webb to continue the subject in a more advanced manner in the present volume. This work, though primarily intended for the Advanced Stage of the Science and Art Department's Examination in "Principles of Agriculture," will also cover the greater part of the syllabus of the Honours Stage.

Care has, however, been taken not to adhere too rigidly to the syllabus in question, and I trust that it may be found equally serviceable for the examination for the Diploma in Agriculture of the Highland and Agricultural Society of Scotland, and the Senior Examination of the Royal Agricultural Society of England.

I presume that every student reading for the Advanced Stage will have first perused the Elementary Text-book, and on this account little has been said in the present volume about "Foods" (except their practical usage), "Ensilage," the theoretical properties of tillage operations, and one or two other subjects. In order to render the book more suitable for the examination of the Highland and Agricultural Society of Scotland, and of greater value to the general agricultural student, a special chapter on "Veterinary Science" has been inserted. This is not required in the Advanced Stage of "Principles of Agriculture," but will, to some extent, bear upon the "Agricultural Hygiene" of the Honours.

Unfortunately for the cause of agriculture and for the scientific world in general, Dr. Webb was never able to complete the work he had begun. Struck down in the midst of a successful and splendid career, his plans had to be carried out by other hands. He was known throughout the length and breadth of the land as one of the first agricultural teachers of his day—a position he had attained by indomitable perseverance, extensive knowledge of the subject, and remarkable ability for imparting instruction to others. His keen foresight has done much to perfect agricultural education in this country, and by his death a vacancy has been left in the leading ranks of agriculturists which it will be difficult to fill.

I have to thank numerous agricultural writers for information upon various subjects. To Professor A. N. McAlpine, B.Sc. (Lond.), I am indebted for the sections on "Farm Crops" and "Seeds" in the chapter on "Agricultural Botany." Mr. H. Thompson, M.R.C.V.S., kindly contributed the chapter on "Veterinary Science." I must also thank Mr. David Young, of the *North British Agriculturist*, for his revision of the proofs; Mr. J. Simpson, for correcting the chapter on "Forestry;" and the Editor of the *Mark Lane Express*, for courteously supplying me with many of the illustrations of Live Stock. In the supervision of the work while passing through the press, I have been assisted by Messrs. H. F. Hill and C. J. R. Tipper, of the Aspatria Agricultural College.

J. LISTER.

THE AGRICULTURAL COLLEGE,
ASPATRIA.

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ADVANCED AGRICULTURE.

PART I.—AGRICULTURAL SCIENCE.

CHAPTER I.

AGRICULTURAL GEOLOGY.

THE primary object of the science of Agriculture is the cultivation and improvement of the soil, as it is from its wealth of food-constituents, built up into appropriate forms by the members of the vegetable kingdom, that animals derive the materials necessary for their development. In order that an agriculturist may acquire a thorough knowledge of the management of the various crops and domestic animals, he should commence with the study of the soil, or Agricultural Geology, and in the present chapter we will, in as brief and simple a manner as possible, endeavour to lay before him the chief points in this subject to which his attention may be profitably directed.

Geology tells us that the crust of the earth is composed of two classes of rocks, stratified and unstratified.

Stratified rocks, which are found in layers one above the other, or side by side, constitute by far the greater part of the earth's crust. But the unstratified rocks, which are mostly crystalline, and therefore in structure like granite, are very important, because it is from the decomposition of these rocks and rearrangement of their constituent particles by the agency of water, that the stratified rocks have been formed.

Definition of a Rock.—In its ordinary sense, the word *rock* is applied to a mass of hard stone; but, geologically speaking, a rock is any mass of material forming part of the earth's crust,

so that clay, sand, or gravel are spoken of as rocks, quite as much as granite and sandstone.

If a piece of granite be examined, it will be found to be made up of several different substances, called *minerals*. The glassy-looking grains which cannot be scratched with a knife are *quartz* crystals. The opaque white or pink crystals, with smooth surfaces of a pearly lustre, are called *felspar*, and the little black masses that split up into a number of glittering plates are *mica*.

Each of these substances possesses properties peculiar to itself, such as a definite chemical composition, specific gravity, crystalline form, and hardness. Such substances are called minerals, and, before we proceed further, it will be desirable for the student to make the acquaintance of the chief minerals which enter into the composition of rocks, and which are known as the rock-forming minerals.

The Rock-forming Minerals.

Quartz—Silica, or silicon dioxide (SiO_2)—is a compound of Silicon and Oxygen—the most abundant mineral on the earth's surface.

It is found crystalline in six-sided prisms with pyramidal ends, very hard and glassy; or irregular masses of quartz-rock; or in small loose grains of sand.

Felspar is a silicate of alumina combined with soda, potash, or lime. When the potash prevails, it is called *orthoclase*, or *potash felspar; albite*, or *oligoclase*, when soda predominates; *labradorite*, when lime is the chief substance in combination.

Clay is formed from the decomposition of felspar.

Mica—of which there are several varieties—consists of silicate of alumina combined with potash, magnesia, lime, oxide of iron, and manganese. It readily splits into thin plates, which have a brilliant lustre, and is found in many crystalline rocks, as well as in slates, shales, and micaceous sands and sandstones.

Amphibole, the chief variety of which is *hornblende*, consists of silicate of magnesia and lime, combined with oxides of iron and manganese, in the form of black or dark-green crystals widely distributed, especially in trap rocks.

—— *Augite* resembles hornblende in composition and physical properties.

Magnetite—*Magnetic Iron* (Fe_3O_4).—Found in large masses or distributed in small grains through the basaltic rocks.

Pyrites—*Sulphide of Iron* (FeS_2).—When in large quantities, exercises a poisonous effect on vegetation.

Kaolin.—Pure clay, a hydrated silicate of alumina. Formed

from the decomposition of felspar under the combined action of carbonic acid and water.

Olivine, or **Peridote.**—A silicate of magnesia and iron, chiefly found in basaltic rocks in the shape of green crystals.

Serpentine.—Hydrated silicate of magnesia. A compact mineral found in large masses and possessing a mottled purple, dark green, or blackish colour, with a greasy feel. Formed either from the partial decomposition of olivine, or from the metamorphism of some sedimentary rocks composed of silicate of magnesia.

Zeolites.—Hydrated silicates of alumina or lime. Readily decomposed by weak acid. Found in the soil in a state of minute subdivision, where they are supposed to take a share in important chemical processes.

Carbonate of Lime ($CaCO_3$).—Found as chalk and limestone in very large masses or formations, and also universally distributed through the soil. In the crystalline form it is known as *Calcite*, of which "Iceland Spar," "Dogtooth Spar," "Nailhead Spar," etc., are varieties.

Dolomite.—Magnesian limestone, consists of a mixture of carbonate of lime and carbonate of magnesia, in the proportion of two of the former to one of the latter.

Apatite ($Ca_3P_2O_8$).—Crystalline phosphate of lime. Found in beautiful green transparent crystals in Canada and the United States; in red opaque crystals in Norway.

The non-crystalline form of phosphate of lime is called phosphorite. It is found in America, Spain, France, and most parts of the world, and is used in the manufacture of superphosphate of lime.

Gypsum ($CaSO_4 + 2H_2O$).—Hydrated sulphate of lime is a very widely distributed mineral. Plaster of Paris is formed from it by driving off the water by heat.

Specimens of these minerals should be examined, and the student should learn to identify them separately, and also to pick them out from other minerals when forming part of some crystalline rock.

We next proceed to gain a general knowledge of the different kinds of rocks.

It has been stated before that rocks are divided primarily into two groups—the unstratified or igneous, and the stratified or aqueous rocks. The unstratified have also been called the primary rocks, from the fact that they must have preceded the stratified, which have been formed from their decomposed and disintegrated fragments.

Classification of Unstratified Rocks.

The unstratified rocks are generally classified in the following manner :—

			Example.
Igneous	Plutonic		Granite.
	Volcanic	ash	Pumice.
		lava	Basalt.
Metamorphic			Gneiss.

Both plutonic and volcanic rocks have at some time been in a molten condition. Volcanic rocks have been thrown out of volcanoes in the form of ash, or have been poured out as lava; the result being that they have cooled rapidly in contact with air. Pumice-stone is an example of volcanic ash. It is porous on account of the small bubbles of steam formerly contained in it.

The rocks formed of lava are chiefly—

Basalt, a dense, heavy, dark-coloured rock, consisting of felspar and augite.

Trachite, consisting of felspar and hornblende, generally of a grey colour and rough to the touch.

Plutonic Rocks have been formed beneath the surface out of contact with air, and subject to great pressure. They have cooled very slowly, and the crystals are much larger than those in volcanic rocks.

The best-known plutonic rock is *granite*, composed, as we have before seen, of quartz, mica, and felspar. The Highlands of Scotland, and the mountains of Devon and Cornwall are chiefly formed of this rock.

Syenite is a variety of granite in which the mica is replaced by hornblende, and the quartz is present only in small quantities.

Felstone is a close-grained rock, consisting of quartz and felspar.

Diorite consists of plagioclase and hornblende. It only occurs in dykes and thick masses which have cooled at great depths.

Metamorphic Rocks.—These are stratified sedimentary rocks which have become metamorphosed or altered by heat or pressure, and whose structure has become more or less crystalline.

Examples of these rocks are *crystalline limestones*, or marble, and *quartzite*, a sandstone, the grains of which have been partly fused and run together.

Slate is shale which has been hardened by intense lateral pressure. The shale was originally deposited in layers, and compressed from above.

Gneiss is composed of quartz, mica, and felspar, the same minerals as are found in granite, but they are arranged in layers.

Stratified Rocks.

These rocks may be divided into three different classes.

(1) **Sedimentary Rocks**, such as clay and sandstone, formed from sediment deposited at the mouths of rivers, at the bottom of the sea, or large lakes. These will be dealt with later on, when considering the distribution of soils.

(2) **Organic Rocks** include rocks formed through the agency of animal and vegetable life, such as chalk, flint, limestone, phosphate, peat, and coal.

(3) **Chemically formed Rocks.**—These include rocks which have been precipitated from water by the gradual drying up of inland seas and rivers. In this way we get beds of sodium chloride, potassium sulphate, as well as gypsum, or sulphate of lime. Oolitic limestone is a chemically formed rock.

Stratified or aqueous rocks differ from igneous rocks in the following points:—

(*a*) They are arranged in regular layers, which have been deposited one above the other.

(*b*) Are formed of minerals which are generally non-crystalline.

(*c*) Are derived from the remains of previous rocks.

(*d*) Contain the fossil remains of animals and plants which existed at the time the rocks were deposited.

Formation of Soils.

The natural agents at work, causing the formation of soils from the crystalline and other rocks, may be divided into two classes.

1. Those which cause *decomposition* and *disintegration*, an effect known as *weathering*, which is followed up and completed by the action of vegetation and animal life.

2. Those which may be called *transporting* agencies.

Weathering, and its causes, will be first considered.

Agents concerned in Weathering.	Physical	Frost. Drought.
	Chemical	Water. Carbonic acid. Oxygen.

All rocks have crevices in them to a greater or less extent, and when these become filled with water a frost will cause the rocks to split by converting the water into ice. This is due to the fact that one volume of water forms 1·09 volumes of ice. The force of the expansion being irresistible, large pieces of rock are separated.

From the same cause also minute crystals are separated from one another, and the crystalline rocks disintegrated.

All changes of temperature cause alternate contraction and expansion, loosening the particles which make up the rock, so that the more changeable the climate the more rapidly does the decay of rocks take place. In a warm dry country like Egypt we see monuments which have stood for thousands of years without much alteration, whilst in a climate like England a hundred years or so will make the carving on a tombstone illegible. In the Arctic regions, where there is continued frost, little action can take place.

Chemical Action of Water.—Water acts chemically on rocks in two ways :—

1. By uniting with one of the constituent minerals forming *hydrated compounds*, as, for instance, clay, which is hydrated silicate of alumina. These hydrated compounds are softer than the original rock, and more readily worn away.

2. By *solution*. There is scarcely a mineral which is not, to a slight extent, soluble in water.

All the constituents of crystalline rocks are perceptibly soluble in pure water, this being especially the case when they are reduced to a state of fine subdivision. As an experiment to show this, powder some felspar crystals, and moisten with pure water. On testing with red litmus paper the colour will change to blue, showing that some of the alkali contained in the mineral has been dissolved.

Carbonic Acid.—Water, in passing through the air and soil, absorbs various gases, especially carbonic acid gas and oxygen.

The potash, soda, magnesia and lime contained in the silicious rocks are seized upon, and slowly converted into carbonates. Thus, in the case of felspar, carbonate of potash, soda, or lime is formed, and the molecule is split up. The carbonate is readily washed out by rain, and the remaining silicate of alumina becomes hydrated, forming clay.

When water contains carbonic acid gas (CO_2), its solvent powers are greatly increased. Carbonate of lime, carbonate of magnesia, and protoxide of iron, which are almost insoluble in pure water, are then readily dissolved.

Water, containing much carbonate of lime, is called *hard;*

when the carbonic acid gas is removed by boiling, the carbonate of lime will be precipitated. It is found as a crust inside kettles.

Another method of rendering hard water soft, is by the addition of lime-water; the carbonic acid combines with the lime to form carbonate, and this is precipitated together with the carbonate of lime in solution, which now falls because it has lost the carbonic acid which dissolved it.

Carbonate of iron is held in solution in the same way.

Oxygen.—This gas is found in considerable quantities in rain water, and is always ready to form oxides with the metals it finds uncombined, or to still further oxidize those substances which are only partially oxidized.

Nearly all minerals contain a large proportion of protoxide of iron cr manganese, and by exposure to oxygen they become converted into higher oxides, and thus assist in the disintegration of the rock. We find stiff blue clay, which contains lower oxide of iron (ferrous oxide, FeO), converted into crumbling red earth, containing ferric oxide (Fe_2O_3) by exposure to air. Iron pyrites (sulphide, FeS_2) becomes converted into ferric oxide and sulphate through the action of oxygen.

Plant Life.—Lichens and mosses grow upon the bare surfaces of rocks, and by their decay furnish a thin film of soil which gradually increases, so that after many generations the higher plants are enabled to grow.

These still further aid in dissolving the rock by their roots, and the carbonic acid set free by the decomposition of vegetable matter.

Animal Life.—The assistance given by earth-worms, ants, and other small animals in the completion of the work of thoroughly pulverizing and reducing the soil to a fine state of division, must not be overlooked.

The earth-worm swallows the earth for the purpose of making its burrows, and for nourishment. The earth swallowed is afterwards brought to the surface and ejected, forming the numerous worm-casts. The importance of the action of the earthworm was first recognized by Charles Darwin. He calculated that about ten tons of dry earth per acre is passed through the bodies of earth-worms, and brought to the surface in the year.

Ants, by their work, also assist in riddling the hedge-banks, etc.

Transporting Agencies.—These are rain, streams, rivers, tides, ocean-currents, avalanches, and glaciers.

Rain exerts a considerable effect by continually beating on the face of rocks, and by dissolving those soluble constituents which have been formed by the decay of the rock. The small crystals

and particles of rock are gradually washed away, till at last they reach the streams and rivers.

After a heavy shower of rain the streams and rivers will be found thick and muddy, from the large amount of materials washed into them by the rain. The more rapid the stream or river, the greater will be the transporting power. If the rate at which a stream flows be doubled, it will move a particle of sand sixty-four times heavier than it could before; or, if it were able to move a pebble weighing one ounce, with doubled velocity it could move a stone weighing four pounds.

The rivers carry the sand and clay out into the ocean, wearing away their banks and beds as they flow, and grinding up the particles of rock and sand together. As the current becomes slower, deposition of the large particles of sand takes place, then the smaller particles, and lastly the mud.

All sands, sandstones, and clays have been formed in this way by deposition from water; consequently we find them stratified in layers.

The dissolved salts, chiefly carbonate of lime and magnesia, silicates, chlorides, phosphates, and nitrates of potash, soda, magnesia, lime, or iron, are carried out to increase the saltness of the ocean.

The coral polype, the calcareous sponges, and the foraminiferæ abstract carbonate of lime from sea-water, and build up their skeletons, which form coral reefs and calcareous ooze at the bottom of the ocean. Chalk is formed chiefly from the remains of foraminiferæ, and limestone formations from fossil corals, and other marine forms of animal life.

The amount of denudation caused by the action of rain is equal to removing one foot of the surface of the land in the valleys in about a thousand years; and this is nine times as rapid as the waste on the table-lands. This does not seem very much, but when we consider the thousands and thousands of years that it has been going on, the amount of work done is more surprising.

Snow has its effect in removing rocks and soil from the sides of mountains during avalanches; but the greatest change has been produced by glaciers, vast rivers of ice, which at one time filled up the valleys between the mountains of Great Britain, resembling those which can now be seen in Switzerland and Norway. These moving masses of ice travel very slowly down the valleys, carrying with them blocks of stone of all sizes, grinding and scooping out the rocks beneath by their enormous weight.

According to their mode of formation, soils are divided into

sedentary and *transported* soils. The last class is subdivided into *alluvial* and *drift* soils.

Sedentary soils are those which have been formed in the place where they are now found. Such soils are found on the Chalk formation, the Lias Clay, and Old and New Red Sandstone.

These soils are seldom of great depth, and their quality can often be judged by examining the nature of the rock beneath.

Alluvial soils consist of materials which have been removed by the agency of running water, and deposited in valleys, along the banks of rivers which overflow, and at the mouths of all large rivers.

The deltas of the Nile, the Rhine, the Mississippi, etc., are examples of large tracts of land made up of materials brought down and deposited by rivers.

The Holderness, in Yorkshire, has been formed from the alluvium brought down by the Humber, and the Wash is being quickly filled up by the vast quantity of *débris* poured into it by the various rivers emptying themselves there.

Alluvium consists of worn rounded materials, which are more or less stratified. Alluvial soils are often deep, sometimes twenty feet; and are generally rich in plant food, being a mixture of decomposing fragments from different geological formations.

Drift Soils have been formed by glacial action; they consist of fragments of rock of all sizes, from grains of sand to enormous boulders of granite. The material is generally deposited without stratification. The stones are often marked on their surface by parallel scratches, which were formed as they moved along with the glacier.

Drift material is often found covering the soil of other formations; for example, the New Red Sandstone north of the Tees is in some parts completely covered with glacial drift.

Geological Distribution.

Stratified rocks have been formed from materials derived from more ancient rocks, that have been removed and deposited in layers by the action of water.

If we examine the geological map of Great Britain we shall find that all the older rocks are situated in the north and west, and that, as we proceed in a south-easterly direction, we meet with a succession of strata coming to the surface (cropping out), each succeeding formation being of more recent origin than the one preceding it.

These strata were originally deposited one above the other,

so that the oldest were below; but, owing to causes dependent on the contraction of the earth's crust, the rocks have been tilted up towards the north-west and depressed towards the south-east, so that the edges of the formations come to the surface.

As a proof of this, we have the fact that a boring for an artesian well, made by Meux and Co., in Tottenham Court Road, passes through the same succession of strata as are met in travelling from London towards Manchester. This has also been confirmed by the recent boring for coal at Dover, where, after passing through the remainder of the chalk, the gault, greensand, and oolite, coal has been reached at a depth of 1204 feet below the base of Shakespeare's Cliff.

The fact that we always find strata arranged in the same definite order, is of great importance to agriculturalists. We always find the New Red Sandstone above the carboniferous coal, *when it is present*, but it must not be forgotten that formations are often absent in certain districts. The subject of distribution of soils is very important and interesting, but cannot be properly understood without a knowledge of geology.

The most recent soils are **alluvial** and **peaty** soils. The only alluvial deposits of any extent occur in the Holderness of Yorkshire and north Lincolnshire, having been formed by the Humber. Another extensive tract of land around the Wash, including the fens and marshes of south Lincolnshire, Huntingdon, and Cambridge, owes its formation to the numerous sluggish rivers flowing through it.

Character.—Generally fertile and flat, except the fen land. The soil around the Wash is divided into the marsh land and fen land. The former is nearest the sea, and consists of finely laminated blue marine clays of great fertility. The other class is of black peaty nature, of not very good quality, but has been much improved by bringing up the Oxford clay from below, and spreading it on the surface.

Peaty Soils are also found widely distributed in Lincolnshire, Cambridge, Bedfordshire, Cumberland, and various parts of Scotland and Ireland, occurring chiefly in low, flat, undrained districts. Such soils are of little use till drained, and treated with lime and clay.

Glacial Drift.—Found in many parts of Scotland, Wales, and the north of England; often masks the underlying rocks, changing the character of the soil.

Tertiary Strata.—*The Crag* forms a narrow strip of fertile land on the east of Norfolk and south-east of Suffolk. *Hampstead beds* of shelly marl and clays are found only in the north of the Isle of Wight.

London Clay.—Found in Middlesex, Essex, and part of Surrey, Berkshire, Hampshire, and Wiltshire.

Character.—Stiff, almost impervious, tenacious, brown or blue clay, expensive to work, except where interrupted by the Bagshot Sands. It is much improved where it meets the upper chalk. Owing to the difficulty in working, much has been laid down to pasture, especially since wheat (which it grows very well) has fallen so low in price. In Hampshire it is covered with the Bagshot sands, a thin, hungry sand.

Secondary Strata.—*Chalk* forms an extensive area in the south-east of England. Starting from Salisbury Plain as a centre, it stretches out in several directions. One broad band extends towards the north-east, passing through the counties of Berkshire, Oxford, Bucks, Hertford, to Suffolk and Norfolk; turning in a north-easterly direction, it passes under the Wash to Lincolnshire and the south-east of Yorkshire, where it is covered to some extent by alluvial deposit. A second arm proceeds due east into Sussex and Kent, forming the North Downs. A third process stretches south-east into Sussex, forming the South Downs; whilst a last extension takes place in a south-westerly direction into Dorset.

Character.—Soils formed from the *upper* chalk are mixed with flints; they produce a short but sweet natural herbage, very suitable for sheep. They often suffer from drought.

The *lower* chalk produces excellent soils, especially when mixed with the upper greensand from below. It is suitable for barley and leguminous crops. In some parts the lime has been washed away, leaving a stiff, brown clay, of poorer quality than the original. Many of these soils are difficult to work.

The Upper Greensand forms a narrow strip of land fringing the chalk.

Character.—Soil very fertile, easily worked, full of fossils containing a large amount of phosphate of lime.

The Gault, of small extent in Mid Kent, Cambridge, and Huntingdon, produces a blue, tenacious clay, very expensive to work.

The Lower Greensand forms unproductive sands in Kent, Surrey, and Sussex, but its area is small.

The Oolite.—Found in the north-west of Yorkshire, whence it extends in a south-easterly direction towards the Wash, and passes underneath the Fens. From the Wash it stretches across towards the mouth of the Severn, sending a branch down to the island of Portland. It is divided into Upper, Middle, and Lower Oolite; and these are subdivided thus:—

Upper: Purbeck beds, Portland beds, Kimmeridge clay.

Middle: Upper calcareous grit, coralline rag, lower calcareous grit, Oxford clay.

Lower: Cornbrash, Bradford clay, Kelloway Rock, Greater Oolite, Fullers' earth, Inferior Oolite.

Character.—Upper Oolite. Purbeck and Portland beds of light character, and only moderate fertility. The Kimmeridge clay is a tough, greyish soil, difficult to work. The pastures on all are fairly good.

Middle Oolite. The Oxford clay is difficult to work, and gives only poor soils. The other beds are of a loamy nature of fair quality.

Lower Oolite. The Cornbrash is very fertile, and grows good corn crops. The Bradford clay gives heavy soils of moderate fertility. The others are of only medium quality, the Inferior Oolite being often very poor.

The Lias Clay extends in a south-westerly direction from the north of Yorkshire, to Lyme Regis in Dorset.

Character.—Consists of a blue clay, more or less mixed with sand or lime. When it is combined with sand, it forms a good loam, but where the clay prevails it is often poor and wet.

There are four extensive vales in this formation running in a north-westerly direction, which are very fertile; these are the vales of Cleveland, Evesham, Gloucester, Berkeley.

New Red Sandstone extends from the mouth of the Tees to the mouth of the Severn; it occupies a large portion of the centre of England.

Character.—This rock produces a deep red soil, generally very fertile, readily worked, and rich. It is chiefly arable, but produces good pastures around Warwick, called the heart of England. It forms good soils in Cumberland.

Magnesian Limestone extends from the mouth of the Tyne due south to Nottingham, a narrow strip widest in Durham.

Character.—Poor thin soil when resting on native rock, but the character is much altered in places by the presence of transported material.

Coal Measures.—Occupy large areas in Northumberland, Durham, Cumberland, Yorkshire, Staffordshire, Warwickshire, Somerset, and South Wales.

Character.—Soils formed are invariably poor.

Millstone Grit extends through Northumberland, Durham, Yorkshire, and Lancashire, flanking the coal measures to the north and west.

Character.—Poor and sterile, except where covered by transported material.

Mountain Limestone forms the greater part of the counties of Northumberland and Derbyshire, and extends into Durham, Yorkshire, and Lancashire, forming the Pennine range of hills.

Character.—Light and poor. Gives good pasture for sheep.

Old Red Sandstone.—Divided into upper, middle, and lower. The upper division forms poor soils, in Sutherland; the middle division runs in a broad band across Scotland, from the Clyde to the Tay, forming very fertile lands in Perthshire. The Lothians are famous for their rich corn-lands. Hops and fruit in Hereford, Devon, and Cornwall, grow well on the soils derived from the middle series of rocks. The tilestones of the lower division give very barren soils in Caithness, Ayreshire, and Lanarkshire.

Primary Rocks (Silurian, Cambrian, Laurentian) occupy the Highlands of Scotland, Cumberland, and Wales. They consist of slates, limestones, and shales. From their elevated positions they are not much cultivated, and are chiefly used for sheep farming.

Old Lava and Trap Rocks are found in Scotland and the north of Ireland. They readily decompose, and yield fertile soils.

Granite is found in Scotland, north of the Grampians, in Cumberland, Mid Devon, and Cornwall; it gives poor and unproductive soils.

General Remarks on Distribution.

Long experience shows that local influences often interfere with the character of the soils which, from geological considerations, we expect to find on certain formations. We should therefore be very cautious before applying the general information contained in the preceding pages to special cases.

One very important fact, well worth remembering, is, *that where two formations meet, we have always an improved soil*, owing to the mingling of the various constituents. *The more mixed the constituents of the soil the better;* hence the fertility of alluvial soils, which are derived from various strata.

There is always a strong family likeness between soils of the same formation.

Formations Characterised by—

Heavy Land.	*Light Land.*
London clay.	Upper chalk.
Gault.	Lower oolite.
Kimmeridge clay.	Magnesian limestone.
Oxford clay.	Yoredale rocks.
Lias.	Millstone grit.

Rich Soils.	*Poor Soils.*
Alluvial deposits.	Upper chalk.
Mixed soils at edges of formations.	Gault.
Lower chalk.	Lower greensand.
Upper greensand.	Oxford clay.
Corn-brash of lower oolite.	Magnesian limestone.
Part of Lias clay.	Coal measures.
Marls of New Red Sandstone.	Mountain limestone.
Marls and cornstones of middle division of Old Red Sandstone.	Cambrian, Silurian, and Laurentian.
Soils formed from the decomposition of basaltic and lava rocks.	Granite.

AGRICULTURAL PHYSICS.

Physical Properties of Soils.

The physical properties of soils depend upon the proportions in which their proximate constituents, sand, clay, lime, and vegetable matter, enter into their composition; so that if we learn the chief physical properties of these substances, we can then have some idea of the nature of the soil which they compose. The properties which we will consider are weight, texture, capillarity, absorbing power, evaporative power, and specific heat, or power of absorbing heat.

Weight.—It is important to compare the weight of different soils. A heavy soil might contain absolutely double the amount of phosphoric acid that a light soil did, although it would show only the same percentage if it were twice as heavy.

Table showing Comparative Weight of Soils.

1	cubic foot of	sand	weighs about	120 lbs.
1	,,	loam	,,	100 ,,
1	,,	clay	,,	80 ,,
1	,,	peat	,,	60 ,,

This shows that a certain percentage of nitrogen or phosphoric acid in a sandy soil indicates a much greater richness than the same percentage in a clay or peaty soil.

The terms *light* and *heavy*, as applied to soils by farmers, have a different meaning to what is generally understood by these terms. They do not refer to the weight, but to the tenacity and resistance they offer to cultivation.

Clay soils are called "heavy" soils because they are stiff and difficult to work. Sandy soils are called "light" because they have very little tenacity, and are easily worked. But sandy soils as regards weight, are the heaviest soils there are, and clay soils are comparatively light. Peat soils are light, both in actual weight, and as regards their texture.

Texture.—The texture of a soil depends upon the state of division of its particles. This varies from large stones, to the microscopic particles found in clay and vegetable soils. Clay is remarkable for the closeness of its texture, or stickiness when wet; and its hardness when dry is caused by the small particles cohering firmly.

Sand does not cohere when dry. Therefore the more sand a soil contains the easier it is to work. Soils adhere to the plough as it passes through, especially when wet. Wet sand offers a resistance of four pounds to the square foot; clays offer a resistance varying from eight to twenty pounds.

Porosity.—The porosity of a soil is a measure of the fineness of its particles; the larger the number of particles, the larger the number of surfaces presented between which water can be retained or condensed together with valuable plant food. Clays are therefore especially of a porous nature, and consequently retentive of water and plant food. Sands are not so porous as clays, and their open texture allows water to percolate rapidly, under the influence of gravity. The combined surfaces of the particles being less in area and further apart, the attraction or adhesive force is much less than in clay soils. The influence of porosity on fertility of soils is very important. Clays have a chemical as well as a physical attraction for substances dissolved in the water passing through, and these substances are to a great extent retained among the interstices of the soil, from whence only the young roots of plants are able to remove them.

Power of absorbing Moisture from the Atmosphere.—Certain substances, if dried and then exposed to a moist atmosphere, have the power of absorbing moisture to some extent. Common salt and magnesium chloride especially possess this power, in different degrees. From the results of a series of experiments carried out by Schübler, the following table has been arranged:—

1000 lbs. of	quartz sand will absorb in	24 hours	0 lbs.	of water.
,,	calcareous sand ,,	,,	4	,,
,,	clay soil (60 per cent.)	,,	28	,,
,,	heavy clay (80 per cent.)	,,	41	,,
,,	pure clay	,,	50	,,
,,	garden mould	,,	55	,,
,,	humus	,,	120	,,

The above table shows that sandy soils are naturally dry, and have a tendency to keep so. In order to improve them in this respect, they should be mixed with clay where possible, or with vegetable matter. Green-crop manuring is very beneficial for this purpose.

Capillarity.—When a piece of lump sugar is dipped into

water, the liquid quickly rises through the sugar between the crystals. In the same way, if small capillary tubes are placed in water, the water rises, and the finer the tube the higher it ascends.

Water rises very rapidly through sandy soils, but to a height not much more than twenty inches.

In sandy soil water rises by capillarity			20 inches.
In loamy	,,	,,	30 ,,
In clay	,,	,,	30 to 36 ,,
In vegetable matter	,,	,,	over 60 ,,

The evaporation from the surface of the land, and the transpiration from the leaves of trees, cause a continued upward flow of water; and as this water contains salts in solution, there is a constant tendency for soluble salts to accumulate in the upper stratum of the soil during dry weather. This occurs to such an extent that in some countries an incrustation of salts occurs during the dry season. The nitrate of potash of India, and the nitrate of soda in Peru, have accumulated to some extent in this manner.

Evaporative Power.—Sandy soils are not only deficient in absorptive power, but what moisture they possess they readily part with by evaporation from the surface.

They also allow water to pass so readily downwards that it is soon beyond the reach of their limited powers of capillarity.

Vegetation increases the amount of evaporation very much. In summer time, during the period of plant growth, three times as much evaporation takes place as in winter; and it has been found that with a bare sandy soil, nineteen parts out of twenty of the rainfall passed through into the drains; but when the same soil was covered with turf, only one-third of the rainfall passed through into the drains, the remaining two-thirds being evaporated, or transpired.

Capacity for Heat.—Soils derive most of their heat directly from the sun's rays.

The radiant heat passes through the atmosphere without affecting it, and is absorbed by the soil; consequently we find the soil much warmer during the day than the atmosphere. The atmosphere, in fact, derives its heat from the soil.

In a series of experiments conducted by Malakuri and Durocher, it was found that when the temperature of the air was 90°, a thermometer placed an inch below the surface gave the following temperatures in soils exposed to the direct sunlight of a July day :—

Quartz sand	126°
Garden soil	114°
Chalk soil	87°

The following may be taken as a summary of the knowledge gained by experiments in Europe and America, and this receives proof from the everyday experience of the farmer :—

1. The more sand a soil contains, the more rapidly will it absorb heat, and the longer will it retain its heat. Hence sandy and gravelly soils are the warmest.

2. The dark-coloured soils absorb more heat than those that are light-coloured. Hence peats are warmer than chalky soils.

3. The more water a soil contains the more slowly will it rise in temperature (because of the high specific heat of water), and the more rapidly will it part with its heat (due to heat being absorbed during evaporation).

4. The amount of heat received by the soil will be affected by its inclination or aspect.

In England land facing the south, and inclined at an angle of 25° to 30°, receives the greatest amount of heat and light.

Subsoil.—By the subsoil is generally meant that soil immediately below the cultivated portion, and which is not disturbed by agricultural operations, except in subsoil ploughing.

It is very important that land should have a suitable subsoil.

In alluvial soils the subsoil is generally of the same character as the soil. Light sandy soils are advantageously placed upon impervious clay soils, and a clay soil resting upon a bed of sand or gravel, is a good arrangement. In both such cases the subsoil may be brought up and spread on the surface with good results.

Open subsoils of gravel are generally disadvantageous, as they allow the escape of fertile matter beyond the reach of the roots. A rocky subsoil is disadvantageous for tillage operations.

For the physical properties of the atmosphere and water, see the Chapter on "Meteorology."

Indications of (a) Barrenness and (b) Fertility.

(A)	(B)
Rocky, picturesque scenery, or sandy plains.	Undulating plains and valleys.
Scarce and ill-grown weeds.	Luxuriance of weeds.
Light colour.	Dark-red or brown colour.
Sandy and dry to touch.	Soft and friable to touch.
Thin soil.	Deep soil.
Aspect north or north-east.	Aspect south or south-west.
Absence of humus.	Presence of humus in good quantity.
Stunted, badly-grown timber, and the presence of heath, sedges, rushes, etc.	Well-grown trees, such as oak, elm, hawthorne, etc.

CHAPTER II.

ON AGRICULTURAL ENGINEERING.

Elementary Mechanics.

Before describing any machines, we will first consider the mechanical principles relating to them.

Centre of Gravity.—The centre of gravity of a body is that point through which passes the resultant of all those forces which, in consequence of gravity, act upon the body. With simple geometrical bodies the centre of gravity coincides with their centres.

Equilibrium.—A body at rest is said to be in *unstable* equilibrium if, after the slightest possible disturbance, it moves away from its former position; in *stable* equilibrium, if it returns to its former position; in *neutral* equilibrium, if it does neither, but remains at rest in the new position into which it has been brought by the disturbances. A cone (1) on its apex, (2) on its base, and (3) on its side illustrates the three cases.

When the vertical line through the centre of gravity of a body falls without the base the body will lose its equilibrium and topple over.

The Levers.—The lever is an inflexible bar capable of free motion about a fixed axis, called its *fulcrum*. There are three kinds of levers: (1) those in which the fulcrum (F) is between the power (P) and weight (W); (2) weight between the power and the fulcrum; (3) those in which the power is between the fulcrum and the weight. Power × its distance from the fulcrum = weight × its distance from the fulcrum.

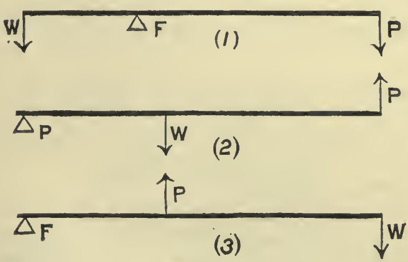


Fig. 1.

Toothed Wheels.—A toothed wheel is a circular plate whose

edge is cut into equal teeth all the way round. When two such wheels are placed so that the teeth of the one fit into the spaces of the other, then if motion be applied, any one of them will turn the other. The weight is suspended from the axle of the larger wheel; the power is applied to the other; then, the axles being supposed to be of equal radius—

$$\frac{\text{Power}}{\text{Weight}} = \frac{\text{number of teeth in P's wheel}}{\text{number of teeth in W's wheel.}}$$

Pulleys.—A pulley is a small wheel, moving freely about an axis, and allowing a cord to pass over any part of its circumference. Pulleys are generally arranged in one of the three following systems: (1) That in which each pulley hangs by a separate cord, one end of which is fastened to a fixed beam, and the other to the pulley above it.

$$W = 2^n P - 2^{n-1} w_1 - 2^{n-2} w_2 - 2^{n-3} w_3, \text{ etc.},$$

where n is the number of movable pulleys; W, weight to be raised; P, the power to be used in doing this; w, weight of highest pulley; w_2, weight of next.

(2) The same cord passes around all the pulleys, which are arranged in two blocks, one of which is fixed while the other bears the weight. This is the most usual arrangement, the others being seldom or never used in practice.

$$W + w = n\,P;\ w = \text{weight of movable block.}$$

n = number of portions of cord in contact with the lower block.

(3) Each cord is attached to the weight.

$$W = (2^n - 1)P + (2^{n-1} - 1)w_1 + (2^{n-2} - 1)w_2 + (2^{n-3} - 1)w_3, \text{ etc.}$$

w_1 = lowest pulley; n = total number of pulleys.

Work.—Work is the act of producing a change either as regards size, shape, or position of a body in opposition to a force which resists that change.

Work is measured by means of two units.

A Foot-pound is the amount of work done in overcoming the resistance due to 1 lb. moving through a space equal to 1 foot. Called the gravitation unit.

A Foot-poundal is that force which will generate in a unit of time (1 second) a unit of velocity (1 foot per second) in a unit of mass (1 lb.). Called the absolute unit.

A Horse-power is a unit commonly used with regard to work. It equals 33,000 foot-pounds.

A horse exerts on the average about 21,000 foot-pounds, an ox 12,000, a mule 10,000, an ass 5000, a man 3000.

Friction.—When a plane on which a body is resting is gradually inclined to the horizon, it will be found that there is a resistance to the motion of the body down the plane. This adhesive force is called friction. If R be the normal pressure between two surfaces in contact, F the maximum friction the substances can exercise, the ratio $\frac{F}{R}$ is called the *Coefficient of Friction.* This ratio varies greatly, as shown by the table.

Wood upon wood (without oil)	$\frac{F}{R} = 0{\cdot}5.$
,, ,, ,, (with oil)	$\frac{F}{R} = 0{\cdot}2.$
Wood upon metal (without oil)	$\frac{F}{R} = 0{\cdot}6.$
,, ,, ,, (with oil)	$\frac{F}{R} = 0{\cdot}12.$
Leather upon wood (without oil)	$\frac{F}{R} = 0{\cdot}63.$
,, ,, ,, (wetted with water)	$\frac{F}{R} = 0{\cdot}87.$
Metal upon metal (without oil)	$\frac{F}{R} = 0{\cdot}18.$
,, ,, ,, (with oil)	$\frac{F}{R} = 0{\cdot}12.$

AIR.

Pressure.—The pressure of the atmosphere varies from about $13\frac{3}{4}$ lbs. to $15\frac{1}{4}$ lbs. per square inch. This pressure supports on an average about 30 inches of mercury or 34 feet of water.

The *Barometer* is an instrument for estimating the pressure of the atmosphere. It consists of a delicate graduated tube, of narrow bore, and closed at one end. In the simplest form it is filled with mercury, and inverted in a small cistern containing mercury, care being taken to prevent any air getting into the tube. The atmosphere presses upon the surface of the mercury in the cistern, and supports a greater or less column in the tube, according to its pressure.

The weight of one cubic inch of air at a temperature of 60° F., barometer at 30 inches, is 0·31 grains.

Windmills.—In order to get the greatest motive power the windmill must be in an exposed condition; the sails should face the wind; and as the ends of the sails sweep around through a greater distance and faster, they should present a flatter surface than the parts nearer the centre. The sails ought, therefore, to have a twist to give them the most perfect form, so that the parts

nearest the centre may form an angle of about 68° with the wind, the middle about 72°, and the tips about 83°.

$$\text{Horse-power of windmill} = \frac{a \times v^3}{1080000}$$

a = area of sails in square feet; v = velocity of wind in feet per second.

HEAT.

Thermometers.—A thermometer is a graduated glass tube, with a bulb at one end, and both ends closed. It contains mercury, or some other convenient substance. The three chief forms are the Fahrenheit, Centigrade, and Reaumer. The former has its freezing-point 32° above zero, and boiling-point 212°. In the two latter the freezing-point is zero, and boiling points 100° and 80° respectively.

In changing Fahrenheit into Centigrade, 32 is first subtracted. I x = any number of degrees, then F : C : R :: $9(x - 32) : 5 : 4$.

WATER.

Weight.—One cubic foot of water at 60° F. and 760 millimetres pressure weighs 1000 ozs. The pressure of the atmosphere supports a column of water from 32 feet to 35 feet high. On gallon of water weighs 10 lbs., roughly.

Flow of Water.—With a straight channel of equal size throughout, the velocity acquired is equal to $0{\cdot}91\sqrt{fd}$, where f is the fall in two miles in inches, and d the hydraulic mean depth; the velocity being measured in inches per second.

Horse-power of Water.—

$$\text{H.P.} = 0{\cdot}00189\ \text{W} \times h.$$

H.P. = horse-power. W = number of cubic feet of water per minute. h = head of water from the tail-race, in feet.

Gauging Water.—Make the water, if possible, pass through a rectangular aperture. Then the number of cubic feet of water discharged over each foot width of sill per minute is equal to $214\sqrt{\text{H}^3 + 0{\cdot}035v^2\text{H}^2}$, where v is the velocity of the water in feet per second, and H is the height of the surface of the water above the sill in feet.

Another method is to take the area of a section of the channel in feet, and multiply this by the velocity in feet per minute. This gives the number of cubic feet of water passing through the section per minute. If this sum be brought to cubic inches, and

divided by 277·274 it will give the flow of water in gallons. One cubic foot of water also weighs 1000 ozs.

Means of getting Motive Power from Water.—On farms where

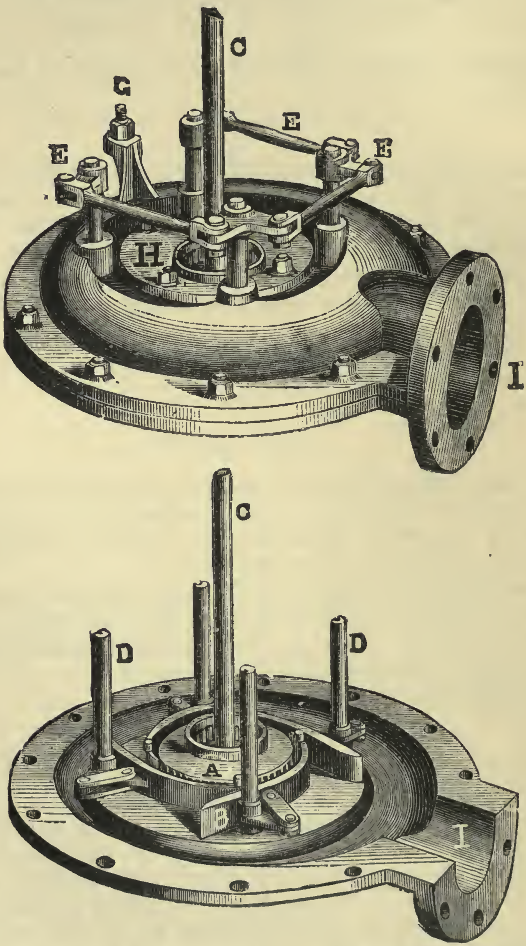


FIG. 2.—External view and section of a turbine. I, inlet pipe; B, guides; A, movable wheel keyed on the shaft C; B, one of the guide-blades; D, the bell-cranks and shafts connecting the guide-blades with the outside bell-cranks and coupling-rods, E; H, wheel-cover.

it can be obtained in sufficient quantities, water is often employed as a cheap and useful motive power. For this purpose, the power is obtained by means of either water-wheels or turbines.

Water-wheels are of three kinds, viz. overshot, breast, and undershot. In each case, the machine consists of a large broad vertical wheel, to the outer rim of which are attached buckets to catch the water. The overshot wheel is the best. With it, the water is laid on near the crown, and by its weight and descending velocity the wheel is turned round. When the fall is not great, breast wheels are most applicable; while for making tidal force available, the undershot is used. From each wheel there passes an axle which, by means of suitable spindles and bevelled wheels, conveys the force to the desired machine. Owing to the machinery being essentially heavy and cumbrous, much of the power of the water is lost. Thus, if the theoretical horse-power of water be taken as 1, then the H.P. of an overshot wheel is 0·68, of breast wheels 0·55, of undershot wheels 0·35.

Turbines (Fig. 2) are a great advance upon the old water-wheels. They consist of an annular case, with inlet and outlet pipes, laid in a horizontal position under water with its axis vertical. Within the case the water is conveyed by means of guide-passages towards the centre of the wheel. Here it comes in contact with a movable wheel, which it causes to revolve. This force is transmitted by means of a vertical spindle to the machine. The water after doing its work escapes, as a rule, by an opening near the centre. The advantages of the turbine are—(1) less primary cost; (2) less cost for erection; (3) gives a greater amount of force than the water-wheel; (4) can be put in places where it would be impossible to erect a water-wheel; (5) revolves at such a speed that it can be applied directly to the machine. By means of a turbine 70 per cent. of the force of the water is rendered available

Steam-Engine.

Before considering the construction of the engine itself it will be as well to briefly describe the boiler.

Boilers.—The boiler may either be intimately connected with the engine, or may be at some distance from it. As a rule the boiler is of cylindrical form, with one or more flues passing through its whole length. About twenty square feet of heating surface are required per horse-power of the engine. The chief forms of boilers are the Cornish, Lancashire, and the ordinary portable-engine boiler.

The Cornish Boiler is a long cylindrical one, having a peculiarity with regard to the arrangement of the flue. This consists of a pipe, which passes through the boiler, the flues come back on the left and right sides, return underneath, and then pass into the

chimney. It all the time keeps in contact with the boiler, and is closely covered by brickwork.

The Lancashire Boiler resembles the former very much, but has two flue-pipes running through its centre instead of one as in the preceding form.

The Portable-engine Boiler.—In this form of boiler the fire can only be applied at one end, and, to recompense for the small amount of heating surface, numerous narrow tubes pass through the water from the fire to the chimney. The hot air and smoke which pass along raise the temperature of the water considerably.

The Parts of an Engine.—These are very similar in all engines. The steam travels from the boiler to the engine by means of the steam-pipe. It passes into the cylinder through the steam-port.

The Cylinder consists of a cylindrical chamber bored out perfectly true, and of the slide-jacket, or valve-box. This chamber is made of cast-iron, and is connected at each end with the slide-jacket by means of steam-ports, through which the steam passes to and from the cylinder. The passage between the two steamports leads to the air or to a condenser, and is called the *exhaust port.* The ends of the cylinder are closed by covers bolted to the flanged ends. The passage is put in communication with either end of the cylinder as required by means of a slide-valve.

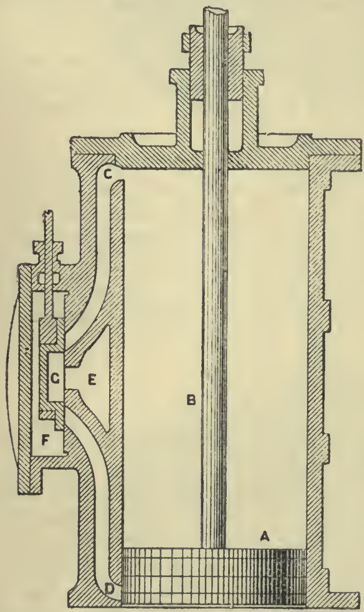


FIG. 3.—Parts of cylinder. A, piston; B, piston-rod; C, D, steam-ports; E, exhaust.

The Piston is the movable plug which works from end to end of the cylinder under the pressure of the steam, and through which the energy of the steam is converted into the motion of the mechanism. It is absolutely necessary that the piston-head must form a steam-tight division between the two ends of the cylinder, and in order to insure this, spring-rings are fitted tightly around it.

Crosshead and Guide-blocks.—The crosshead is at the outer end of the piston-rod, and it is to this that the connecting-rod is

attached by means of a pin passing through the crosshead. Guide-blocks are sometimes attached to each side of the crosshead in order to prevent the oblique thrust or pull of the connecting-rod from bending the piston-rod.

The Connecting-rod connects the crosshead with the crank-pin, and by its means the to-and-fro motion of the piston-rod is transformed into the rotatory motion of the crank-pin. The length of the connecting-rod varies from two to four times the length of the "stroke" of the engine, that is, the distance travelled by the piston-head from one end of the cylinder to the other. The longer the connecting-rod, within certain limits, the better, as the rotatory motion will be effected with less strain upon the piston.

The Crank.—The crank consists of an arm with a boss at each end, one to take the main shaft and the other the crank-pin. The crank is moved in a circular manner by the connecting-rod, and in its turn causes the main shaft to revolve.

The Fly-wheel is a large wheel fixed to the main shaft, and having an outer rim of heavy metal. By its weight and consequent momentum it tends to prevent sudden fluctuations of speed. The driving-wheel of locomotives answers the same purpose.

The Eccentric consists of a circular disc generally rotating about the main shaft, which does not, however, pass through its centre. The distance from the centre of the disc to the centre of the shaft is called the "eccentricity" of the eccentric. This mechanism consists of the disc called the "sheave," surrounded loosely by a thin metal hoop, the "strap," to which is attached a connecting-rod. The parts are so arranged that, while the sheave revolves in a swinging manner, the strap, and consequently the connecting-rod, have a motion resembling greatly that of the main connecting-rod.

Slide-valves.—In the cylinder there are three openings—two outside ones, called steam-ports, which conduct the steam to or from the cylinder and the steam-pipe; and a middle one, larger than the rest, called the exhaust-port. The latter allows the spent steam to escape into the air or be conducted to a condenser. These ports are covered by the slide-valve, which is shaped somewhat like a hollow rectangular inverted dish. The edges of the dish, constituting the face of the valve, are planed and scraped to a perfectly true plane surface, and this works on a similarly prepared part of the cylinder face. The amount by which the valve overlaps the steam-ports when at the middle of its stroke is called the *lap;* this may be outside or inside. By the motion of the connecting-rod the slide-valve is pulled backwards and

forwards, closing and opening the valves in turn. Thus, while steam is getting into the cylinder by one steam-port, the waste steam is escaping by the port into the exhaust-port on the other.

The Governor is fitted to an engine to secure as far as possible a uniform rate of speed. It consists of a central spindle, to which are attached a couple of heavy balls by means of two elbow joints. The spindle is made to rotate by a small shaft, driven from the engine-shaft, which has a bevelled wheel communicating with another at the bottom of the spindle. A belt may be used instead to give the motive-power. When the central spindle revolves rapidly the balls fly out more and more by centrifugal force, and, by pulling outwards and upwards the arms, raises or lowers a collar. To this collar a system of bent levers pass to the throttle valve. When the balls are far out the connecting-rod partly shuts the throttle-valve, and thus allows less steam to get into the cylinder.

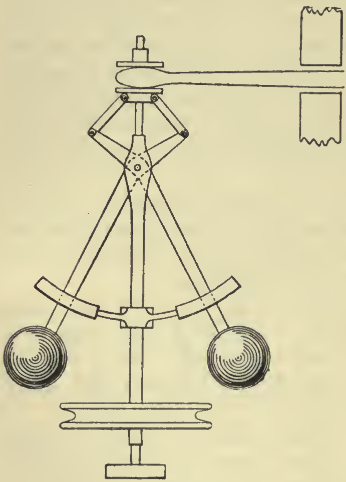


FIG. 4.

The Throttle-valve is a circular disc, working in the steam-pipe close to the cylinder, and capable of turning on its diameter as an axis, thus admitting or shutting off steam as required.

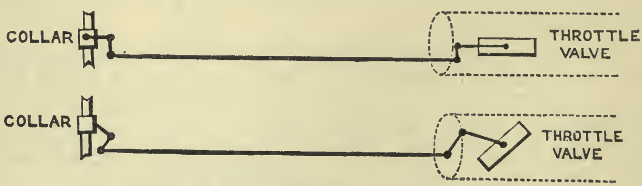


FIG. 5.

Safety-valves provide for the safety of the boiler by allowing the steam to escape when its pressure exceeds a certain limit. There are three principal forms :—

(1) Dead-weight safely-valves, kept in their places by a dead weight immediately over the valve.

(2) Where the valve is kept in its place by a weight at the end of a lever.

(3) Spring-loaded safety-valves, kept in their places by means of powerful springs.

Condensers.—The condenser is a box or chamber into which the steam, after doing its work in the cylinder, is passed and condensed instead of being exhausted into the air. The object of the condenser is (1) to remove as far as possible the effect of atmospheric pressure from the back of the piston by receiving the exhaust steam and condensing it to water, thus creating a partial vacuum, and (2) to enable the steam which acts on the piston to be expanded down to a lower pressure than can profitably be done when the steam exhausts into the air. There are "jet" and "surface" condensers. In the former, the steam, on coming out of the cylinder, is met by a spray of cold water. In the latter, the condensation is performed by means of a cold metallic surface.

Beam-engines.—In this form the piston raises and lowers a large beam, forming a lever of the first class. From the other end a rod descends which rotates the crank.

Compound Engines.—These have two cylinders, a high-pressure and low-pressure. The steam is admitted first into the former, which is the least. After doing its work here it passes into the other side of the low-pressure cylinder. The piston-head is pushed back, and as fresh steam is admitted into the small cylinder at the same time there are thus two forces assisting each movement.

Horse-power of Steam-engines.—

$$\text{H.P.} = \frac{P \times L \times A \times N}{33{,}000}$$

P = Mean effective pressure in pounds per square inch on the piston. L = Length of stroke in feet. A = Area of the piston-head in square inches. N = Number of strokes per minute, or twice the number of revolutions per minute.

A good engine uses about 2 lbs. of coal per horse-power, but this amount is often exceeded.

Oil-Engines.

These engines are designed for using the common oils, such as petroleum and the ordinary lamp-oils, but creosote and the heavier oils can be employed.

The following description applies chiefly to the "Trusty" oil-engine of Weyman and Co., but they are all on much the same principles.

It is an engine upon the four-cycle principle—that is, an

impulse is obtained every other revolution; no other principle will give as good results. There is the engine proper, a small oil-pump and a vaporizer, the latter being placed at the end of the cylinder.

The oil is poured into a small tank, which is separate from the engine, and can be placed in any convenient position in the engine-house; this is connected by a small pipe to the pump, which is actuated by the governor of the engine.

As the engine requires it, a drop of oil is pumped automatically into the vaporizer, where it is vaporized, and as the engine draws it into the cylinder, air in excess is also drawn in through a separate valve. Upon the charge being compressed, it is fired by an ordinary ignition tube, which is kept hot by means of a small blowpipe.

To start the engine the vaporizer is first heated, which takes

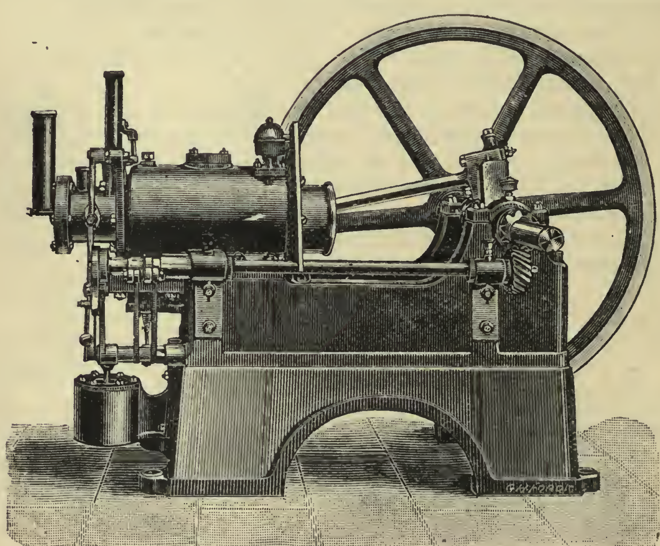


FIG. 6.

about ten minutes, a few drops are pumped into the vaporizer, and by turning the fly-wheel once or twice the engine starts. After this, little attention is needed, as the amount of oil in the tank is enough to last for a long time. About three-quarters of a pint per horse-power per hour is consumed.

The principle is simple. The compressed mixture of oil

vapour and air is ignited, and by the expansion thus produced the piston is forced forward.

The only objection to these engines is the cost.

Gas-Engines.

Gas- and petroleum-engines are somewhat alike in their action. The "Otto" gas-engine, by Messrs. Crossley, is undoubtedly the best of its class, and is now brought to a great state of perfection. The action of this engine is as follows. Gas and air are drawn into the cylinder by the forward stroke of the piston, it is then compressed by the return stroke, and the gas is fired at the end of the second stroke, or first revolution. The air and gases not used up in combustion at once expand with the heat, press upon the piston, and drive it forward, whilst the products of combustion, etc., are exhausted by the return stroke of the piston, at the end of the second revolution. Thus gas and air are admitted and fired every second revolution. The gases are also exhausted every alternate revolution, the firing-valve being opened at the end of the first and third, and the exhaust at the end of the second and fourth.

Connected with the cylinder are three valves. The first (a double one) admits gas and air; the second is the firing-valve, and the third the exhaust. These valves are all opened by the action of a cam fixed on to a shaft, which is revolved at half the speed of the crank shaft, from which it is driven and regulated by means of bevelled wheels.

The firing takes place by means of a small gas jet which is always burning just outside the firing-valve. The cylinder is kept cool by means of a water-jacket. The valves are all fitted with strong springs, so that they close immediately they are slipped by the cam.

These engines are made in almost all sizes, from half-horse power upwards, and may be used for almost all purposes. They are considered to be preferable to oil-engines when the gas can be taken from the main at a reasonable price, but for portable purposes the oil-engines are more suitable.

Agricultural Implements.

Horse-cultivating Implements.—By the use of these implements the farmer is able to procure a state of tilth which will be most suitable for the growth of his crops. They include ploughs, grubbers or cultivators, harrows, and rollers.

Ploughs.—There are very many kinds of ploughs, but the most common are those ploughing one furrow at a time. These often, but not always, have wheels.

The parts of a plough, as seen in Fig. 7, consist of:—

(1) The handles. These are made of either iron or wood, and are so constructed that the ploughman has the greatest possible control over the implement when ploughing. They are held together by light rods, which generally cross each other in a diagonal manner.

(2) The frame. This carries the working parts of the plough.

(3) The beam is a strong iron bar, to which the horses are yoked.

(4) The bridle, or hake. The depth and breadth of the furrow-slice are regulated by this part of the plough. The hake has notches, by means of which the chain, which is also attached to the whipple-trees, can be moved up or down, in the former

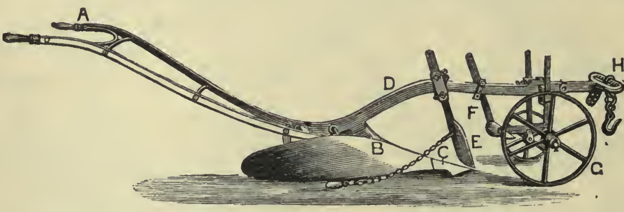


FIG. 7.—Parts of single-furrow plough. A, handles or stilts; B, mouldboard; C, share, or sock; D, beam; E, coulter; F, skin-coulter; G, wheel running at bottom of furrow; H, bridle with hook; I, wheel running on top of ground.

case causing the plough to go deeper into the soil, in the latter reversing this action. The hake can also be moved laterally. If a wider furrow-slice is required, it is moved to the right; if it is already too large, it is moved to the left.

(5) The wheels. These are not always present, as can be seen in the Scotch swing ploughs. They come after the bridle, and are generally two in number, *i.e.* a large furrow-wheel on the right, and a smaller land-wheel on the other side. The former runs in the furrow and, to a great extent, regulates its depth. Thus, when a deep furrow is desired, the wheel is set higher. The wheels are fastened to the beam by means of an upright bar and a cross bar going horizontally. There is also a beam-clasp fastening the parts together. By keeping the furrow-wheel farther from the beam a wider furrow is obtained.

(6) The coulter. This is a large knife, making the vertical cut in ploughing. Its upper part is often cylindrical, and is fastened to the beam by two clasps, one above and the other below the

beam. Its lower part broadens out, the landside being kept flat, and the other sloping away. The point should come near the share.

(7) The skim coulter works in advance of the last, and acts in a similar manner to a small plough, turning over and burying the first inch or two of the soil.

(8) The share cuts the furrow-slice in the bottom, and is fixed to the sole of the plough. The best kind is the chilled share, in which the edge is always kept sharp by the upper part alone wearing away.

(9) The mouldboard is a large cast-iron plate fastened firmly to the plough frame. It is elongated, and so constructed that it causes the furrow-slice to move through a spiral curve, and thus turns it upside down.

(10) The slade is a smooth flat bar attached to the under part of the body, so that the plough runs smoothly upon it.

The above applies chiefly to the single-furrow plough, but the same parts are found in nearly all ploughs.

Turn-wrest Ploughs.—These are also called one-way ploughs, from the fact that they always turn the furrow-slice on one side, thus doing away with the wide open furrows between the ridges. They are of various designs. Thus, in one kind, the mouldboard can be turned over from one side to the other; in another form two mouldboards are used, one standing vertically upwards while the other does the work for the time. Again others are arranged on the balance system, similar to steam ploughs, or have two mouldboards placed back to back. In the last plan, one mouldboard works one way, and then the parts are swung round, so that the other has to turn the furrow.

Digging Ploughs.—These have a short concave mouldboard, and thus break up the furrow-slice when turning it over. The land is left in a friable state.

Double-furrow Ploughs.—Turn two furrows at once, and as they only require three horses and one man, the cost of a horse and a man is saved. The work is more quickly done, and pans do not readily form in the soil.

Multiple-furrow Ploughs.—Take three or four furrows at a time. The work is done more quickly, but it is best for these ploughs to be drawn by steam-power.

Double-mouldboard Ploughs are chiefly used for making up ridges, as for turnips and potatoes. They have a mouldboard on each side, and thus an equal amount of soil is thrown up to both right and left.

Subsoil Ploughs.—These consist of an ordinary plough frame, with no mouldboard, and with a subsoil body, which simply cuts

through the soil but does not raise it. (Fig. 8.) (See "Subsoiling," p. 290.)

Cultivators, or Grubbers.—These consist of a framework, resting on wheels, and carrying tines which point forward in an oblique manner. These tines either have chisel points or are broadened out like shares. (Fig. 9.) The advantages of the cultivator are: first, it opens up the land well, but does not bury

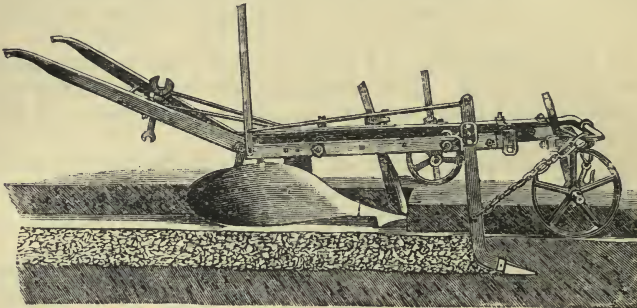


FIG. 8.—Subsoil plough.

the fine surface mould; and, secondly, it draws out the long underground stems of couch unbroken.

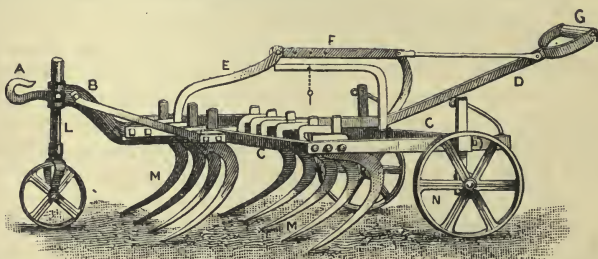


FIG. 9.—Parts of cultivator, or grubber. A, draught hook; B, beam; C, frame; D, lever for raising tines; E, arm connected to lever; F, catch for lever to hold tines into work; G, handle of lever; N, hind wheels; L, front wheel; MM, tines or teeth.

Harrows.—The harrow consists in its general form of an iron frame carrying teeth, usually descending perpendicularly. They do not rest at all on wheels. The best harrows are made of iron, and are very often of zigzag form. Ransome and Co. have a patent jointed harrow which follows all the inequalities of the ground, but as a rule the frame is rigid.

Harrows may be conveniently divided into two classes—heavy and light. The former, also called drag-harrows, are used for

breaking down clods and exposing fresh surfaces to the atmosphere. The teeth of this kind are often curved. The light harrows only require one horse. Varieties are used for brushing in the seed of cereals or grass and clovers, and for levelling the surface.

Chain harrows are made up of chain links in some particular form, and are perfectly flexible. They are used chiefly on arable

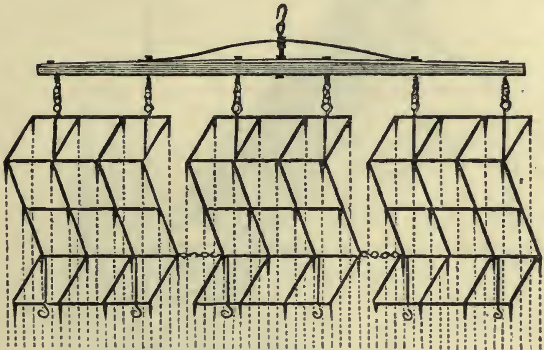


FIG. 10.—Scoular's diagonal harrow.

land for collecting weeds, and also on pastures for spreading manures.

Rollers.—These implements are generally of iron (stone rollers are sometimes used), from about fourteen to twenty-six inches in diameter and five to eight feet long. They consist of one or more cylinders strung end to end upon a common axis. The roller should be in at least two sections, to facilitate turning. When properly made, one section moves forward and the other backward whilst turning, and thus no injury through scrubbing the soil results.

Croskill Roller, or Clod-crusher.—This consists of numerous discs, having projecting teeth, all placed upon the same axle. The discs are of two sizes, and large and small are strung alternately. The larger discs also have large holes for the axle, and thus revolve in a swinging manner. The advantage of this is, that if any clod of earth get into the roller it is speedily worked out by the larger sections. This roller weighs about one and a quarter tons, and requires three or four horses. The ordinary rollers for heavy land weigh about 18 cwt., for light land 12 cwt.

Cultivating Implements actuated by Steam-power.

For the systems of steam-cultivation, viz. the single- and double-engine methods, see the chapter on "Tillage," p. 280.

Ploughs.—Steam-ploughs are mostly made so as to balance about a couple of wheels. They consist of two rigid iron frames, to which are fixed from two to six plough bodies. These two

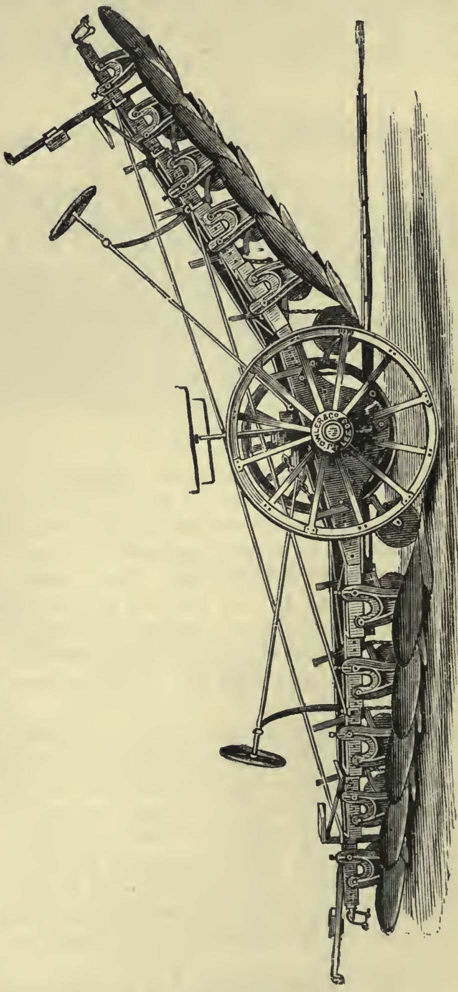


Fig. 11.—Fowler's patent-balance plough.

parts are so arranged that, while one is working, the other is elevated, and is let down at the headlands. To each half is fixed a seat and steering-wheel. Instead of the ordinary mould-

board, digging-breasts can be placed, and thus the soil is completely pulverized.

Subsoil ploughs can be very well worked by steam-power. Besides the ordinary ploughs, they have strong tines attached, which follow in each furrow, and break up the subsoil to any required depth. Three or four plough bodies and tines are usually attached to each part.

Cultivators.—These are made either to balance, or to turn round at each headland. The former are somewhat similar to the plough; except that, in the place of the mouldboard and coulter, strong tines are substituted, capable of working to a depth of two or three feet. In the other form three wheels are used, one in advance of the other two. These support a strong iron frame, carrying from five to thirteen teeth. By means of a special turning-lever the tines are lifted, and held out of the ground when at the headland; the machine is pulled round, the tines released, and the backward journey commenced.

Harrows.—The chief steam-harrows are like the turning cultivator with a harrow frame and teeth, in the place of those of the grubber. In some forms the teeth have a slight forward slope, instead of descending perpendicularly. They also are sometimes double-pointed.

Steam-diggers.—Some very effective machines of this form have been brought out lately. In one form the engine travels across the land, and has the digging-apparatus connected to the back of it. This consists of very strong oscillating arms, with steel prongs. The advantages claimed for it are: (1) It breaks up the land well, and leaves it in a better condition than ordinary ploughing and harrowing. (2) It is cheaper, as it does as much work per day as ten horses and five men, only requiring one man in attendance. (3) It breaks up pan subsoils. (4) The engine can be used for other purposes besides digging, the forks being easily taken off. The Darby digger is not so simple in form, and travels sideways when digging. It has six strong digging-forks, and cultivates a width of twenty-one feet at a time, to a depth of not greater than fourteen inches.

Harrows and Drills.—As a drill in itself is very light, it is usual to fix one or two harrows on the frame as well. A heavy harrow, before the drill, renders the soil fine; while a light one, coming after, covers in the seed. By this means, all the operations are performed at once.

Discers.—These machines consist of a frame, supported by about four wheels, and carrying two or three rows of thin discs, which cut up the surface soil.

Sowing Implements.

Drills.—By means of these machines, the farmer is enabled to sow his seed in a more regular manner, both as regards the amount sown, and the depth and distance apart of the seed tracks. Drills vary greatly, and need to be of somewhat different form for various soils and various seeds. Thus small heavy seed, like clover, would generally be run out of the drill more quickly than light grass seeds, if some adjustment were not made.

Cup-drills.—In these the two large wheels support a frame on which rests a long box. This box is divided into two parts, the upper called the hopper, and the lower containing the cups. In the lower chamber an axle runs the whole length, and to this axle are fixed numerous discs to which the cups are attached at right angles by small stalks. When the drill is in motion, the seed trickles down from the hopper into the cup-barrel. The axle, supporting the discs and cups, is made to revolve by means of either cogged wheels or a small belt working from the main axle. Each cup, when passing through the seed, takes up its share; and then, when nearly in the highest position of the disc, empties it into the funnels. The seed then falls down the spouts, and is deposited just behind the coulter, in the track made by that body. The above principle holds good for many kinds of drills. To several of these implements there is a lever attached by means of which the distance between the drills is easily regulated.

Chain-drills.—In these the seed falls from the hopper on to an endless chain, which conveys it to the funnel.

Force-feed Drills have the discs and cups replaced by a small roller with spiral groovings, which carries the seed to the funnels, exactly in the same manner as an endless screw.

Tooth and Brush Pinion Drills, and Disc Drills have numerous holes in the bottom of the seed-box, covered in the first case with a revolving pinion bearing teeth alternating with brushes, and in the latter kind by a disc with wavy edges. By these means the seed holes are first closed, and then opened, and the seed is also worked out.

Manure- and Water-drills.—There are many forms of the dry-manure drills. In some, the fertilizers are deposited by means of cups, the hopper being in this case large, and provided with a stirrer. When seed and manure are both to be drilled, the operation is usually done at once, by having two hoppers, etc., and depositing the artificials a little in advance of the seed-coulter. But it is not always desired to drill the seed, and here the manure-drills come into play. These consist of a cylinder,

formed of a number of rings, each having projections coming in contact with scrapers beneath the box. A stirrer is used to mix the substances up thoroughly. The manure is distributed broad-

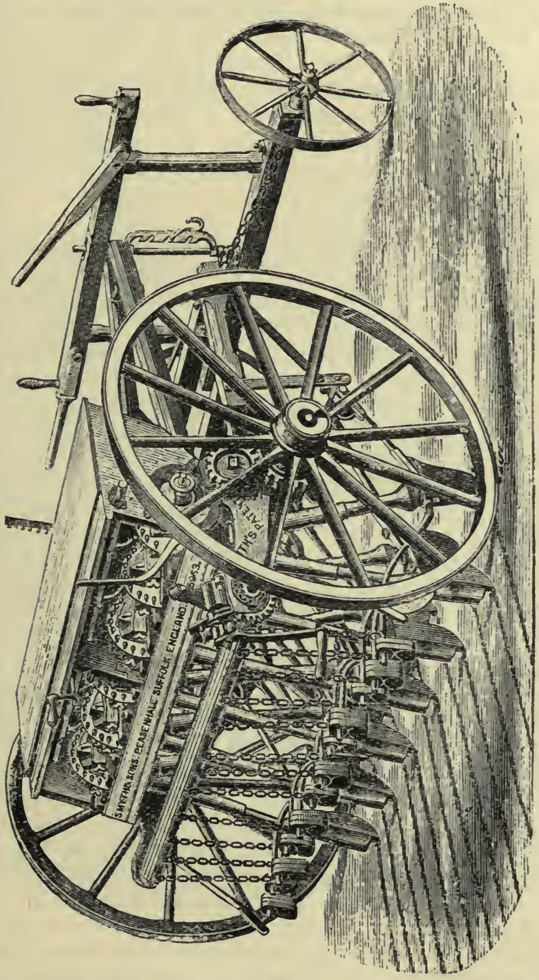


FIG. 12.—Nonpareil corn-drill.

cast. In another form the barrel itself revolves, and allows the artificials to fall upon a rotatory distributor which spreads it evenly over the land. Again, in another manure-drill the substances are

carried to the funnels by means of an endless chain, worked from a shaft at the back of the machine.

In liquid manure drills, the fluid is placed in a large tank, which occupies the place of the hopper. By means of cups on discs the liquid is poured into the funnels and down the spouts.

The Broadcast Barrow consists of a long box, of nearly triangular section, set across a barrow frame. The bottom of the box is pierced by numerous holes through which the seeds drop. From end to end of the hopper runs a brush spindle, deriving its motion from the travelling-wheels. The machine is wheeled along by a man, and the seed, which is placed in the box or hopper, is swept out by the brushes. A width of about twelve feet is sown at once.

Broadcasters.—The seed is passed into the funnels as in the ordinary cup- or disc-drills. The spouts are short, and flattened out at their lower end, which rests upon the distributing-board. On the distributing-board are numerous rows of pegs, arranged in triangular form; the apex of each triangle being very near a spout end. The seed, therefore, on coming out of the spout is spread out, and is scattered evenly over the ground.

Potato-planters.—These vary greatly from the other forms of seed-drills. They have a large open hopper for the potatoes, through which passes an endless chain, revolving on a drum, or else a disc. Attached to the chain are either cups or steel needles, which take a potato each during the revolution through the hopper. The sets they let fall down a wide spout, and finally drop into the bottom of the furrow. The cup-planters seem to be the best. Some potato-planters cover over the sets, and thus finish the work.

Strawsonizer.—The body of this machine rests upon a couple of iron wheels, three or four feet in diameter, and three inches wide. It is drawn by one horse attached to the pair of shafts. The machine is used for distributing seeds, manures, insecticides, etc. This is done very effectively by means of a strong blast from a fan, secured to the body. A spur-wheel, eighteen inches in diameter, is keyed on to the road-wheel axle, and works a pinion fitted to a second motion-shaft. This consists of a spur-wheel, actuating a pinion, keyed on to a third motion-shaft. The latter carries a pulley, fourteen inches in diameter and two inches wide, which, by means of a small belt, works a pulley on the fan. The fan is about nine inches in diameter, and has close sides. The inlets are four and a half inches in diameter, and the delivery pipe is three inches wide, and discharges to the rear. The seed or manure is placed in a large wooden hopper, arranged over the delivery-pipe of the fan, and fed down by means of a stirrer

and one roller. For seeds the roller is smooth, but for manures and similar substances the roller is serrated. The seeds, as they fall into the blast, strike against an adjustable fan-shaped plate of eleven inches radius, fitted with six radiating distributing partitions, one inch high. The seeds are thus spread out in fan-like form.

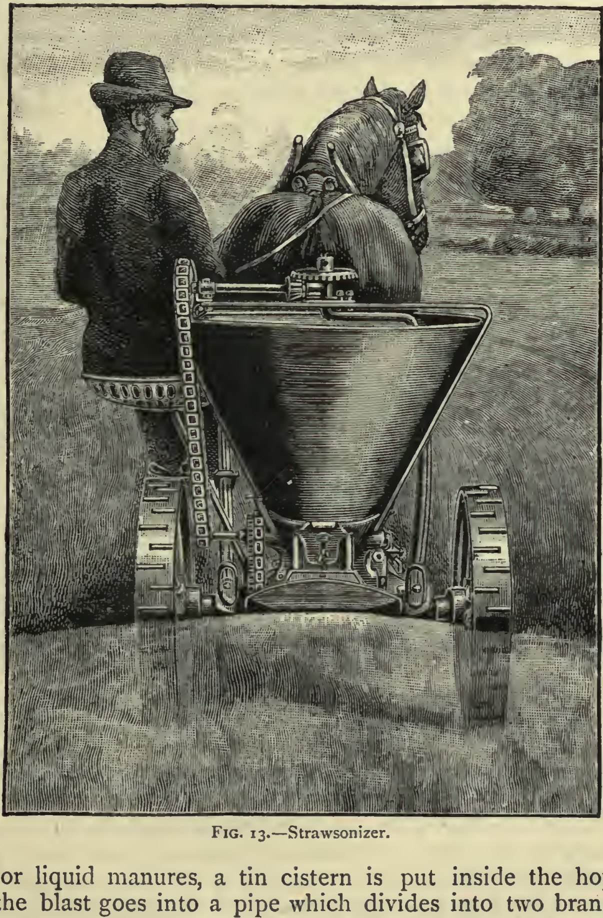


FIG. 13.—Strawsonizer.

For liquid manures, a tin cistern is put inside the hopper, and the blast goes into a pipe which divides into two branches, having five terminations each. A flexible hose leads from these up into the cistern. The pipes in each case have a slight upward turn, so that the seeds or manure are spread out much further.

Hoeing Implements.

Horse-hoes.—The multiple horse-hoe takes two or more rows, and is supported by two large wheels, to the axle of which is fixed a horizontal bar, from which the shares descend. These consist of an upright stem with a sharp flat blade, which works in the soil and cuts through any weeds. The blades are of different shapes, and can be put at varying distances apart by means of a lever. The hoe-blades cut in parallel lines, leaving the young plants, and destroying the weeds between the drills. The machine is usually governed by means of a lever, enabling the driver to keep it in the proper lines.

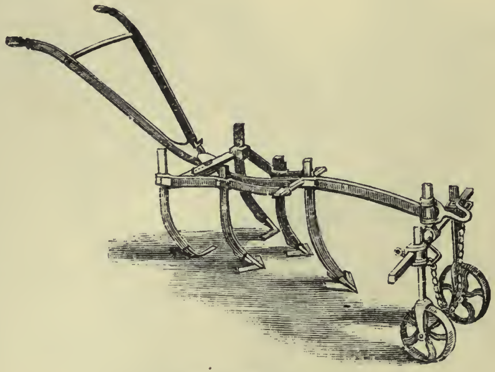


Fig. 14.—One-row horse-hoe.

Scufflers and one-row hoes are very much like cultivators. They have from one to three wheels, and a frame of triangular shape, from which descend the tines. These vary in number, but in the one-row hoes are generally three, in which case the back tines have long feet.

Implements employed in securing Crops.

Mowing-machines are used for cutting grass, intended for hay. They are generally drawn by two horses, attached to a long pole coming between them. The frame, to which this shaft is fastened, is supported by two broad wheels. From these wheels the motion for the cutting apparatus is derived in two ways. In the first case, a pinion wheel is worked by the travelling-wheel, which has teeth on its inner rim. The pinion is carried on a first-motion shaft, fitted with ratchet-boxes and pawls, which only revolves as the machine goes forward. On this shaft is a bevel

wheel communicating with another attached to a long shaft passing to the front. This shaft turns a crank disc, to which is attached a connecting rod, running across the front of the machine. In the second method the travelling-wheels communicate their forward motion to the main axle itself, through ratchet-boxes and pawls. From the main axle the motion is transmitted to the front in a similar manner to the action of the other machine. To the connecting-rod the knife is fastened. It consists of a steel bar with sharp triangular projections in front, so that it acts somewhat like a horse-clipper. The knife works in a flat bar called the finger-beam. To this bar are attached a number of finger-like projections, having a space cut out towards their back in which the knife works. At the outer end of the beam is a small wheel, and a dividing-board.

Reapers, used for cutting corn, are chiefly of three kinds, viz. manual-delivery reapers, self-delivery reapers, self-binders.

Manual-delivery Reapers.—This differs little from the ordinary mowers, except that at the back of the finger-beam is a rack which is held up in an inclined position by means of a lever. This

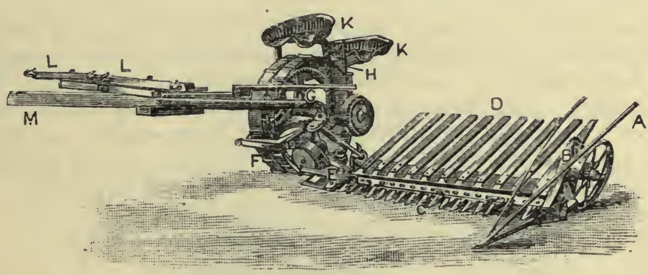


FIG. 15.—Manual delivery reaper. A, track board; B, offside shoe with wheel; C, fingers; D, rack; E, connecting rod; G, lift-lever; H, gear-lever; KK, seats; LL, swingle-trees; M, pole.

ever is controlled by the foot of the person on the machine. The divider at the extremity of the finger-bar towards the standing corn is also slightly different. The corn, when cut, is packed upon the rack, until enough has been accumulated to make a sheaf. The rack is then lowered, and the corn pushed off behind by a rake, after which it is raised. Two persons generally go with this machine, one driving, and one "putting off" with the rake.

Self-delivery Reapers are of two kinds, viz. those with back delivery, and those with side delivery. The principle of each is, however, very similar. Besides the ordinary cutting apparatus, they have an upright shaft carrying four revolving rakes. By means of these, the cut corn is gathered upon a platform behind

the knife. One of the rakes then sweeps the corn off the platform, which in the side-delivery reaper is shaped somewhat like a

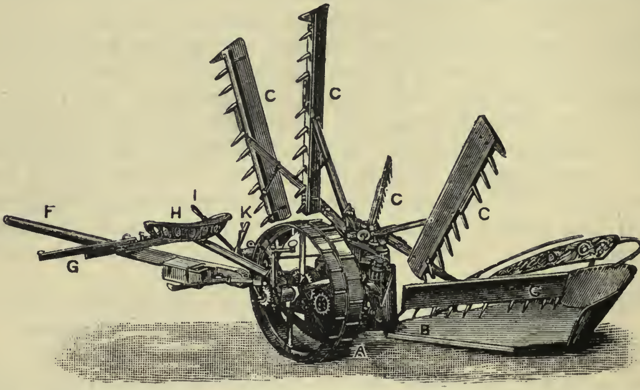


FIG. 16.—Self-delivery reaper. A, main-road wheel; B, platform; CCC, rakes or sails; D, divider-board; F, pole; G, swingle-trees; H, seat; I, tilting-lever; K, gear-lever.

quarter circle. On some machines each rake sweeps off part of the corn, which is thus left on the ground in the form of a swathe.

Self-binders are much more complicated machines than the preceding. The grain, as it is cut, falls across an endless web, which conveys it over the top of the driving-wheel, and then down an incline until its progress is stopped by the packers.

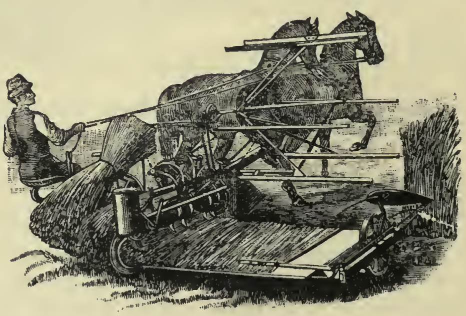


FIG. 17.—Self-binder.

These consist of a couple of curved levers, which hold the grain until a certain previously determined weight, enough for a sheaf, has accumulated. Then the needle, which is of nearly semi-circular form, rises from below with the twine, and passes in front

and then over the sheaf. The band is then caught hold of by the knotter, which ties a very secure knot. This is done by the string being wound once round the jaws of the knotting apparatus, and then part is pulled through this ring, and the knot pulled tight. The string is then cut, and the sheaf ejected from the machine in a horizontal position by a pair of levers provided for the purpose.

FIG. 18.

Hay-makers are also known as tedders. They consist of a number of steel prongs attached to heads, which are fixed by shafts to the main axle, or to another axle worked by cogged wheels from the travelling-wheel. Usually a guard is placed in front, to keep the hay from being tossed forward. Tedders have two actions—one in which the hay is lifted by the prongs, brought round in front, and then thrown out behind with some force. In the other method, the arms revolve in a contrary manner, and, coming down in front, take the hay off the ground and gently throw it out behind. In the latter way the material is simply turned over, and is much in favour where there is any quantity of clover, as it suffers very much from severe tedding.

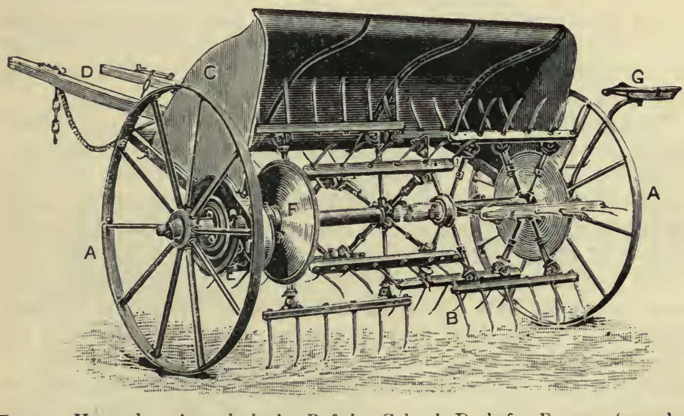


FIG. 19.—Hay-maker. A, road-wheels; B, forks; C, hood; D, shafts; E, cover of gear-box; F, guard; G, seat.

Horse-rake.—These machines consist of a light frame resting on two wheels, and drawn by one horse. To a bar, running from side to side just above the axle, are attached a number of long curved teeth, skimming the ground. The machines are now

generally provided with a seat for the driver. When sufficient material has been collected by the teeth, the driver puts in action

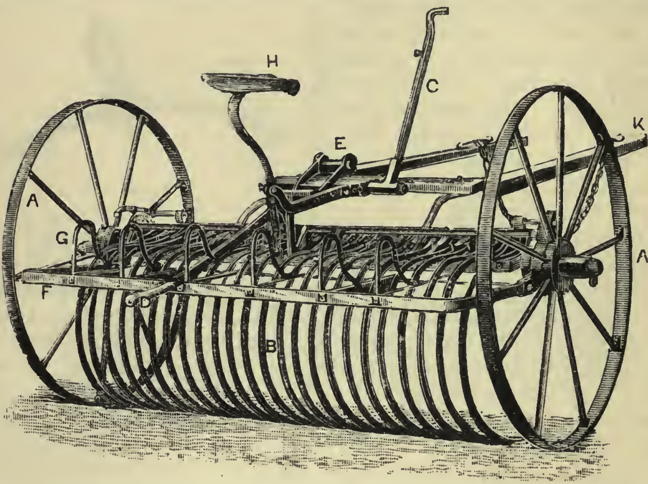


FIG. 20.—Self-acting horse-rake. A, road-wheels; B, teeth; C, hand-lever (front); D, back hand-lever; E, foot-lever; F, back frame; G, clearing-rods; H, seat; K, shafts.

a lever which raises the teeth, and leaves the hay lying in a row. When riding, this lever is usually worked by the foot; but when the attendant has to walk behind the machine, the lever is lengthened and worked by hand.

Rick Lifters.—For removing ricks up to twenty hundred-weights in weight. They consist of a sparred or boarded platform, set on low wheels, and to the front of which shafts are attached, after the manner of a tip-cart. At the front of the platform a simple windlass is fixed, connected with a wheel on which a rope is coiled. When it is desired to remove a rick, the machine is backed up to it, and the clutch which holds the platform to the shafts is unlocked, when the hind part falls. The edge of the platform is then pressed under the hay, and two ropes from the windlass are fastened round the rick. A horse is then attached to the rope on the wheel, and, by moving forward, gradually pulls the rick on the platform. When well on, the front of the platform drops down, and is automatically clutched to the shafts. The load is then drawn away.

Mr. John Spiers, of Newton, near Glasgow, was the first person to construct machines of this type, that were at all satisfactory.

Horse Forks.—These machines are constructed on two principles: (1) as in the mason's shears for lifting stone, but, instead

of only one prong on each side, there are two or three; (2) the fork is similar to a harpoon, with a controllable barb on the end.

In building an oblong or circular rick, a pole is erected close to its base, and on this are fastened guy ropes to keep it in position. A light jib or gaff moves up and down or around the pole, and from its peak hang down the hoisting rope and fork. The rope is conveyed over pulleys down the pole to near the base, where it is attached to a horse. The fork having been loaded, the horse moves forward, and by so doing raises the load, which is dropped by the person in charge on any part of the rick. In a shed the rope, etc., are attached to a small carriage, running along a rod stretched close under the ridge.

Elevators are generally used for stacking straw or hay, although the same principle is very often used in raising other materials. The elevator consists of a long trough, mounted on a frame

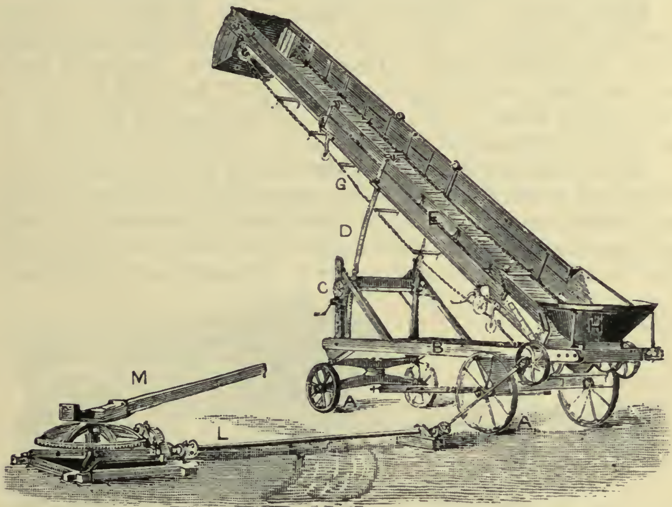


FIG. 21.—Elevator. AA, travelling-wheels: B, frame; C, cogwheel for raising the lifting-rods, D; E, trough in which material travels; G, endless chain, with forks for carrying the material up E; H, hopper for receiving material; L, connecting-rod from horse-gear, M.

supported by wheels. An endless chain passes up this, and returns over pulleys on the outside. Attached to this chain are steel prongs, which carry up the materials.

Potato-raisers.—The working parts of these are usually attached to the back of the machine, and consist of a broad blade, which cuts through the bottom of the ridge, and several revolving

arms which knock out the potatoes. The tubers usually strike

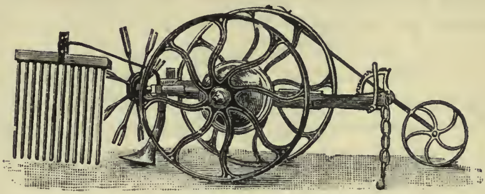


FIG. 22.—Allan's potato-raiser.

against a hanging vertical screen and drop in a row. The arms derive their motion in a simple manner from the main axle.

CARRIAGES.

Carts.—The single-horse Scotch cart is one of the best agricultural vehicles. It is drawn by means of two shafts attached to the rectangular body. This rests upon a strong axle joining the two wheels, which are about four and a half feet in diameter. They carry about a ton weight. At the back of the cart is a movable "endboard."

The wheel requires special notice. It will be noticed that a cart-wheel is dished toward the centre, and the end of the axle-arm is bent, so that, while the lower part of the wheel is vertical, the top slopes outward. The centre part of the wheel is called the "nave," or "hub" when metal. Through a slot in the end

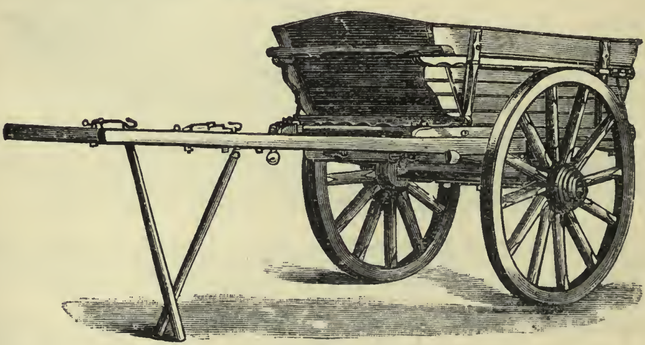


FIG. 23.—Cart.

of the axle there passes a linch-pin, which prevents the wheel from slipping off. A "bush" or "box," usually of cast-iron, is fitted tightly into the centre of the nave—of such a size as to work

round the axle without friction. In the nave regular holes are cut, into which are fitted the "spokes," generally twelve in number. At their outer end the spokes are morticed into the felloes, six in number. The felloes, again, have projections fitting into each other. Around the whole wheel an iron rim or tyre passes tightly, and holds the parts together.

Waggons.—These are not in general use. They rest on four wheels, the front pair of which are made so that they can run under the body of the waggon when turning. They are usually drawn by two horses.

It has been proved that carts, as a rule, are lighter of draught than waggons. This is because in the former case the horse partly bears and partly pulls the load; while in the latter case it pulls it entirely. For long journeys in which frequent rests are necessary, the waggon would be the better.

For increasing the area of the cart, during hay-time and harvest especially, a sparred wooden frame is placed upon the cart, so that it projects over the sides.

Implements for preparing Crops for Market.

Thrashing-machines.—In order to understand the action of this important machine, the vertical section, shown in Fig. 25, should be studied. The corn is fed regularly into the drum-mouth over the feeding-board, and is then caught by the beaters of the drum. By the action of the beaters it is nearly all knocked out of the ears, and falls through the concave, while the straw and some of the grain are carried on to the shakers, which are worked backwards and forwards by the cranks. The seeds, etc., are thus roughly separated from the straw, which passes out of the machine at the end of the shakers. The grain, chaff, etc., from the concave and shakers fall upon the inclined oscillating receiving-board, and from thence on to the caving-riddle. The seeds and chaff drop through this, but the cavings are carried to the back, and drop over a tail-board to the ground, just behind the straw. The remainder, by means of the riddles, are divided up into proper grain, seeds of weeds, and chaff. The second mentioned fall through a fine riddle and down a spout. By means of blasts of air from the fan, the chaff is blown out from among the rest of the grain, and passes through a suitable exit. The grain falls through another riddle or two, receiving blasts from the fan, and then passes down the inclined plane to the bottom of the elevator. The latter consists of dredging-cups attached to an endless chain or belt working round the two pulleys. These empty the corn into the hummeler, or awner, which separates the awns of barley and

all adhering chaff. The corn, chaff, etc., all fall upon the riddles, where they receive an air-blast, by means of which the light impurities are blow out to the receiving-table. The grain next drops into the rotatory wire screen, which is divided up into three or four sections, having the wires at different distances apart. The use of the screen is to divide up the corn into different qualities.

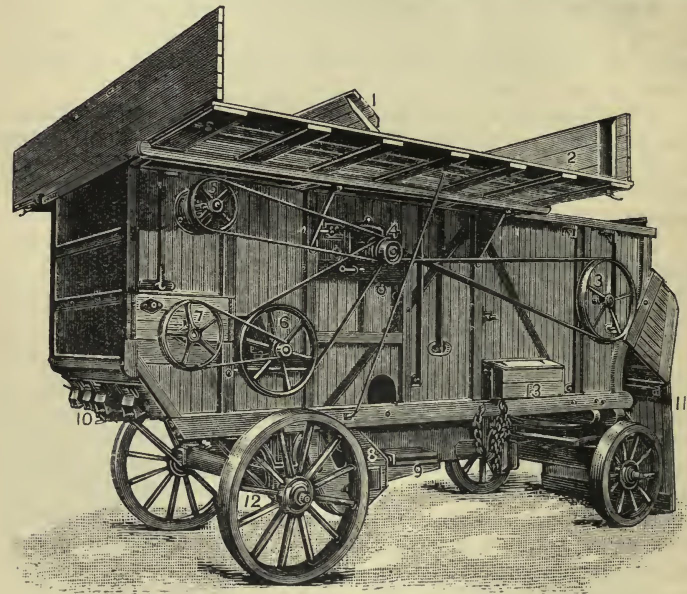


FIG. 24.—Thrashing machine.

Thus, to begin with, the wires are near together, and consequently only the thinner and poorer seeds can drop through. The best corn passes out at the other end of the screen, without going through the wires. The corn, as it passes through, falls down suitably placed spouts into the bags.

To most machines there is now attached apparatus for binding the straw. When this material comes out from the shakers it is caught by two revolving canvas aprons, and carried to the inclined binding-table. Here it is bound in two places, fifteen or eighteen inches apart, in the same manner as done by the self-binding reapers.

Winnowing-machines.—These are used when the thrashing-machines belong to the single-blast kind—that is, when they do not finish the cleaning of the grain. The corn is fed from a hopper,

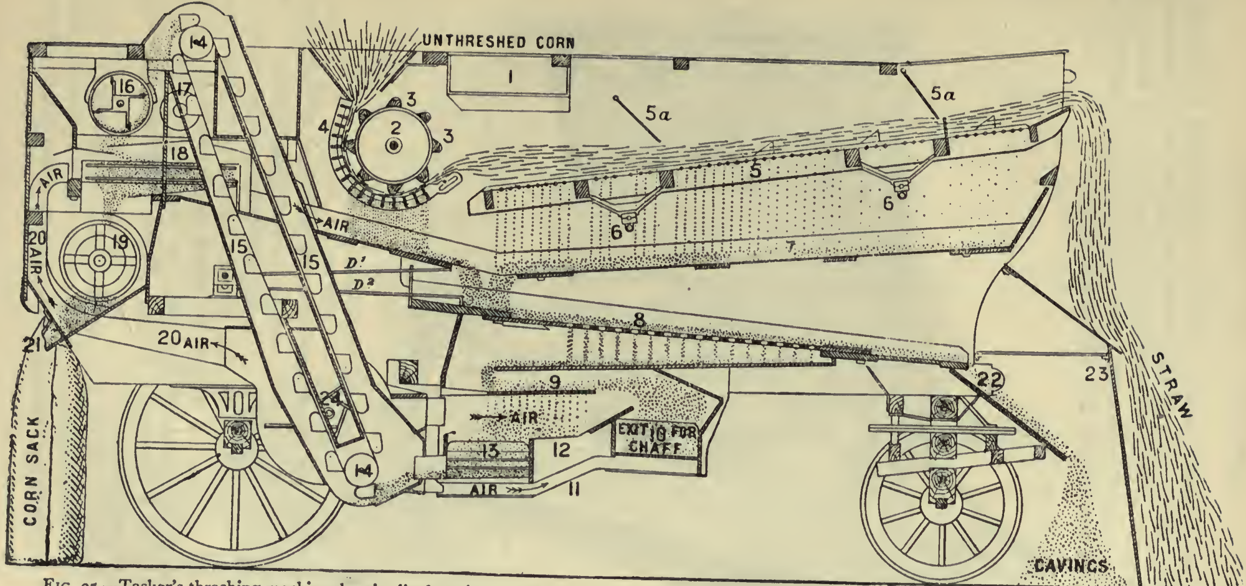


FIG. 25.—Tasker's thrashing machine, longitudinal section. 1, feeding box; 2, drum; 3, beaters; 4, concave; 5, strawshaker; 5*a*, hinged boards for retarding motion of straw; 6, cranks of shaker; 7, first receiving board; 8, caving riddle; 9, riddle; 10, chaff-sieve; 11, passage for air blast; 12, winnower; 13, corn-sieve; 14, pulleys to corn-elevator; 15, corn-dredging cups; 16, awner or hummeler; 17, conveyor; 18, corn-winnowers; 19, revolving screen; 20, air blast; 21, corn spout; 22, exit of cavings; 23, straw-board; 24, fan.

and falls upon several oscillating riddles. By the aid of a strong fan-blast the chaff and very light seeds are blown out by a special opening; the good grain falls on an inclined screen, and comes out at one end. In some cases the grain is then taken upwards by the cups of an endless chain, and run into a sack.

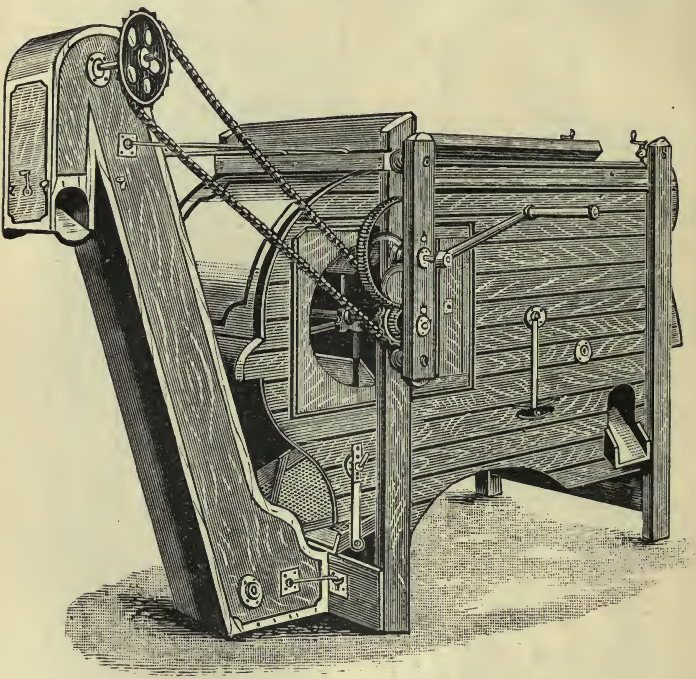


FIG. 26.—Corbett's winnowing-machine.

Corn-screens.—Corn-screens are not provided with fan-blasts. The seed falls from a hopper upon a wire screen, which may be of various forms. Sometimes it is flat, sometimes cylindrical as in the "rotary" screens. In the former kind the screen is either made to oscillate, or is struck by some small hammer. In any case it is endeavoured to separate the impurities by having the wires at special distances apart. These machines are usually turned by hand.

Hummelers.—These are often attached to the thrashing-machines, as before shown. They consist of a cylindrical barrel, in which revolves an iron shaft with knives and beaters attached,

The barley falls in from a hopper above, and is then subjected to the action of the knives and beaters, which deprive each grain of awn. The grain afterwards passes down an inclined spout, generally constructed so as to act as a kind of screen and get rid of the awns.

Hay- and Straw-presses.—Hay and straw are very bulky, and hence dear for carriage. Various steam, horse, and hand-presses have been invented to reduce the bulk of these materials. The steam-power press which gained first prize at the Royal Agricultural Society's Show in 1888, resembled a square pipe in which the material was plugged, and pressed in well by six lateral latches. These were worked by a connecting-rod. In other machines various applications of levers, screws, etc., are employed to give the necessary pressure.

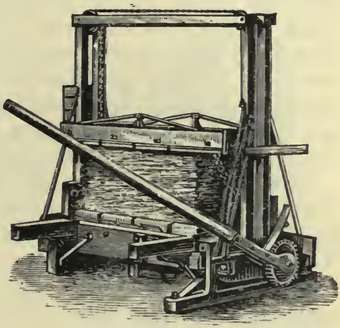


FIG. 27.—Hay-press.

IMPLEMENTS FOR PREPARING CROPS FOR HOME CONSUMPTION.

Corn-mills.—It is well known that crushed grain is more economical as food for stock than whole. The grinding is done by means of one or two fluted rollers, mounted upon a frame. In some mills the roller is of conical form, and works in a corresponding fluted concave. The grain falls in at the narrow end of the roller, and is worked onwards by means of spiral blades on the axle bearing the roller. The crushed corn drops out by a spout at the broad end of the roller. In other mills the roller is cylindrical, and works within a fluted concave. Again, there are often two rollers to each mill, working against one another, and turning in opposite directions.

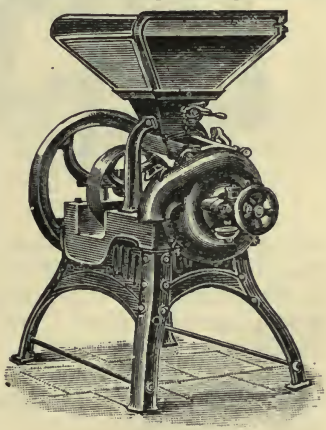


FIG. 28.—Corn-mill.

Chaff-cutters vary in size from small hand-machines up to

those driven by steam-power. They consist essentially of a large wheel carrying knives upon its arms. In the smaller kinds there are only two knives, but others bear as many as six. The material to be cut is placed in a long trough, and is drawn forward by means of toothed rollers. The knives revolve rapidly past the mouth of the feeding-trough, and cut up the straw or other material into lengths of about an inch. The chaff then drops down into some receptacle placed on the ground. With the larger kinds of chaff-cutters there is often a bagging apparatus attached, especially when worked in connection with the thrashing-machine. The chaff is taken by means of an endless chain to a sufficient height, and then drops into the bags.

To all the latest chaff-cutters there is a reverse lever attached. Should the attendant get one or both of his hands in the machine, he has simply to push the lever to one side with his shoulder and the action of the rollers is reversed.

Turnip-cutters are of two kinds—the barrel and the disc patterns, the former being the most common. They consist of a cylindrical barrel, turned by a handle, and having rows of knives arranged in V form. This is placed upon a proper frame, and has above it a large hopper for the turnips. On the disc principle, the knives are fitted on an iron disc so that they radiate from the centre. They have chisel-pointed or curved teeth.

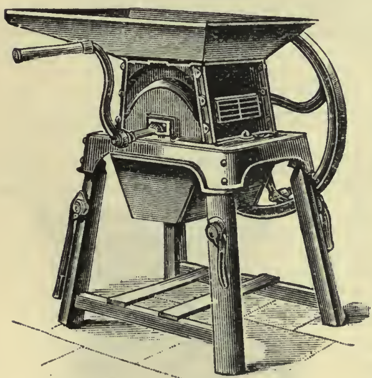


FIG. 29.—Turnip-cutter.

Pulpers are used to cut the roots into much finer shreds than cutters. Like the latter they are of both barrel and disc kinds, but the disc patterns are much the better. They have from four to six knives fitting radiately upon the disc, each divided up into a great many cutting points.

Cake-breakers.—The cake is broken by means of a pair of rollers, carrying teeth. The machine is usually turned by a handle on a large fly-wheel. The axle of this turns one roller, and the other is worked by cog-wheels from it. The broken cake slides down a perforated plate, through which the dust passes into a box.

Gorse-mills.—The working parts consist of two revolving cylinders, made up of saw-like discs, separated by washers. The

discs work in between each other closely, and thus the gorse prickles get very well crushed.

Root-washers consist of an open cylinder, partly immersed in water, contained by a trough-like part of the body. Into the cylinder the roots are put, sometimes by means of a hopper, and sometimes by raising part of the frame. It is then revolved by a handle, and when the washing is sufficient, the cylinder is raised out of the water, and the potatoes or roots taken out. One root-washer has an archimedian screw in the cylinder to hold the potatoes. While turning one way the roots are well washed, but on reversal they are worked out at the side.

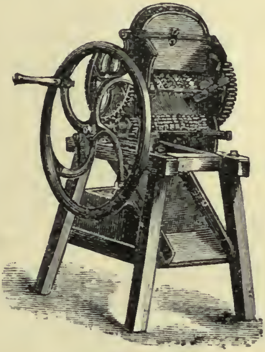


FIG. 30.—Cake-breaker.

Cooking Apparatus.—Where an engine belongs to the farm it is often advisable to employ the waste steam in cooking food, especially roots and chaff, for the stock. All that is required is a large rectangular or cylindrical steamer, into which the steam from the boiler is conducted by a pipe. The apparatus is filled with the food material and covered over with a lid, and then the operation can be commenced. On many farms, however, there is no engine, and here specially constructed boilers and steamers are used.

CHAPTER III.

AGRICULTURAL CHEMISTRY.

A.—*Chemistry of the Soil.*

One of the most important, if not the most important, of the subjects to be studied by the agriculturalist, is that of the Chemistry of the Soil, under which is included not only the classification and composition, but also all the changes taking place in the soil.

Several classifications of soils have been proposed, each having various merits; but perhaps the best, or at any rate the commonest, is the classification according to the predominance of one of what have been called the "proximate constituents" of the soil. These proximate constituents must not be confounded with the chemical elements contained in the soil. They are components which can be separated by a comparatively rough analysis, and are themselves of a compound nature. They are Mineral Fragments, Sand, Clay, Carbonate of Lime, and Organic matter.

Such an analysis could be conducted in the following manner.

A sample of the soil is taken, care being exercised that it is a representative one. In mentioning this, it might be well to call attention to the rules of the R.A.S.E. with reference to this. They are—

"Have a wooden box made six inches long and wide, and from nine to twelve deep, according to the depth of the soil and subsoil of the field. Mark out in the field a space of about twelve inches square; dig round, in a slanting direction, a trench, so as to leave undisturbed a block of soil with its subsoil from nine to twelve inches deep; trim this block so as to make it fit into the box; invert the open box over it, press down firmly, then pass a spade under the box, lift it up, and gently turn it over.

"The sample is thus in the exact position it occupied in the field."

If a field is uneven in character several samples are required.

Of course these rules are made for the guidance of any one sending samples of soil away for analysis; but still it is a very good method to employ even when a rough analysis is to be made.

From the sample of soil the stones are removed and weighed.

Next, a representative portion of the sample which has been air-dried is vigorously agitated with distilled water and thoroughly boiled. After cooling, the agitation is repeated and the muddy liquid poured or siphoned off. This is repeated until the water on being shaken up no longer becomes muddy.

We have now the sand and gravel in one glass, and the fine mud or clay in the other. Both are allowed to settle, and the clear water in each case decanted off, and placed on one side.

The clay and sand are collected, dried, and weighed, then strongly ignited on a clean iron plate and again weighed. The loss represents the organic matter. The water which has been placed on one side is then evaporated to dryness, and the residue weighed. This gives the matter soluble in water. The carbonate of lime is much more difficult to estimate, and its exact determination is beyond the scope of the present volume. Its presence in considerable quantity can be indicated by adding hydrochloric acid to the soil, when a brisk effervescence will be observed, and at the same time a gas will be evolved, which, if collected and shaken up with lime-water, will turn it milky. This gas is carbon dioxide. We have now obtained—

Stones or mineral fragments.
Sand and organic matter } total
Clay and organic matter } organic matter.
Matters soluble in water.

Having thus obtained some idea of the composition of the soil, by reference to the subjoined table we would be enabled to classify the soil under one of the heads.

Sandy	under 10 per cent. clay.
Sandy loam ..	10 to 20 per cent. clay.
Loam	20 to 30 per cent. clay.
Clay loam	30 to 50 per cent. clay.
Strong clay ..	over 50 per cent. clay.
Marly	5 to 20 per cent. of calcic carbonate.
Calcareous ..	over 20 per cent. of calcic carbonate.
Humus	over 5 per cent. vegetable matter.

By *sand*, as mentioned above, is meant silica (SiO_2) or quartzose sand, but the term has usually a wider application; for instance, we speak of micaceous sand, where the silica is mixed with a large quantity of mica, which can easily be detected, as

it exists in the form of small shiny plates, readily adhering to the fingers. We also speak of shell sand, which, as its name implies, is the result of the breaking down of shells by the wearing action of the sea, and which, therefore, consists chiefly of carbonate of lime.

Clay is a more complicated substance than the former, though in reality, paradoxical as it may seem, what is called clay consists mainly of fine sand, so fine that it is no longer gritty to the touch, and is tenacious and pasty when mixed with water. It, however, contains also in varying proportions another substance, viz. hydrated silicate of alumina, or pure clay, though the proportion of this compound even in strong clay soils is comparatively small. *Lime* or carbonate of lime is met with in nearly all soils to a fairly large extent; and some, as, for instance, those of the chalk downs, consist almost entirely of it.

Organic matter, or humus, is usually the remains of previous vegetation or of manures, such as farmyard manure, which contain considerable quantities of vegetable matter. As this vegetable matter becomes thoroughly incorporated with the soil it forms humus, and gives to it the dark colour which is so characteristic of virgin soils. Humus consists of various forms of organic matter in different stages of oxidation. Its composition is consequently complex, variable, and imperfectly understood. As would be supposed, it contains a considerable amount of carbon, some of which is supposed to be present in the form of various organic acids, as ulmic, geic, and humic acids, etc.

In addition to this it contains a great deal of water, and always compounds of nitrogen.

The proportion of nitrogen to carbon has been given as one to twenty-three.

These "proximate constituents," with the exception of the organic matter, have all resulted from the disintegration of rock; indeed their origin can be traced back to the oldest of existing rocks. We do not, however, here propose to trace the soil in its descent, nor to follow it through the wonderful metamorphoses which it has undergone, changing from rock to soil, and from soil to rock; but merely to show by one or two examples the *chemical* changes which take place in the breaking down of rocks, taking granite on the one hand, and, among more recent rocks, limestone. Any one living in a district where granite is abundant must have been struck with the difference in appearance between a block of that substance which has been exposed to the air for a lengthy period, and the inside of that block as disclosed by fracture, or the surface of another piece which has

been buried under the ground or otherwise protected from the atmosphere. Very often pieces of rock may be found which at first sight appear to be masses of quartz crystals, and it is only on breaking them that the presence of the three minerals of which granite is composed, viz. quartz, mica, and felspar, reveal their true character; at the surface, the felspar and the mica have entirely disappeared, leaving only the harder quartz, and eventually the whole of the granite would become disintegrated.

The chemical agencies which are instrumental in bringing about these changes are the same which are responsible for the greater portion of natural chemical actions: they are oxygen, which is found in the atmosphere to the extent of one-fifth; carbon dioxide (CO_2), which exists as an impurity in the air to the amount of four volumes in 10,000; and water.

It is the felspar in the granite which is first attacked. This felspar is a complex substance, a compound silicate of alumina, potash, and iron. The iron is readily attacked by oxygen of the air, and rust or ferric oxide (F_2O_3) is formed. The carbon dioxide then acts upon the silicate of potash, forming carbonate of potash and probably some soluble silica; and these, being soluble, tend to get washed away. The silicate of alumina remains, and, having taken up water to replace the potash, forms hydrated silicate of alumina, which more or less mixed with impurities, especially oxide of iron, forms clay. There is yet, however, mica and quartz in the granite, but they do not resist the disintegrating influences.

The mica—which consists of silicate of alumina, and magnesia combined with potash, lime, and iron—may, by its decomposition, form further supplies of clay, and yield up its other compounds to enrich the newly formed soil, or it may simply become pulverized by the many agencies, such as frost, friction, and change of temperature, which produce this effect, and go to form a micaceous sand.

The quartz, or silica, in time becomes ground up by mechanical agencies, and forms sand.

We have, therefore, from the granite both clay and sand—the latter of two kinds,—in addition to compounds of potash, soda, or lime, etc.

Of the means Nature employs to separate and transport the clay and sand and pile them into thick beds, of the innumerable mechanical agencies she uses to supplement the chemical effects, of the methods, organized and unorganized, she employs to once more build into rock the disintegrated material, it is not our intention here to treat; but should the student care to study

further the interesting science of the life history of our soils, he will find it more fully dealt with in works on geology.[1]

The chemical changes which bring about the conversion of limestone (carbonate of lime) into soil are very similar, except that in this case the change is much more rapid and apparent, and is brought about principally by the agency of CO_2 dissolved in water. When water contains this gas dissolved in it, it has the power of readily dissolving the limestone, and most fantastic shapes are worn by the continued action of such water. No one who has crossed a limestone fell can have failed to be struck by the variety of forms assumed by the scattered rocks, or by the number, size, and depth of the fissures worn in rock by this agency. Nowhere can thi effect of weathering or disintegration be better seen than on the face of a limestone quarry which has been out of use for some years. The continued percolation of water, supplemented, of course, by mechanical agencies such as frost, etc., soon destroys the artificial appearance, and the sloping mass of *débris* at the foot of the cliff, together with the scattered blocks, some of which are tons in weight, give it altogether the appearance of a natural precipice.

We have spoken of the "proximate constituents" of soils, and have to some extent dealt with their origin; but a knowledge of these by no means indicates the composition of the soil, nor gives any clue to its capabilities. To understand these we must obtain a knowledge of the chemical composition of the soil. It is often argued that no information of practical value to the farmer can be gathered from a chemical analysis, and if such analysis be made by a chemist who has no knowledge of agricultural practice the statement may be true; but carried out by one who has made a special study of the subject it becomes invaluable.

The following, in the opinion of the late Dr. Voelcker, are the points on which a chemical analysis will give definite information.

1. As to whether or not barrenness is caused by the presence of some injurious substance, such as sulphate of iron.

2. Whether soils contain common salt, nitrates, or other soluble salts that are useful to vegetation in a highly diluted state, but injurious when too abundant.

3. Whether barrenness is caused by the absence or deficiency of lime, phosphoric acid, or other essential soil constituents.

4. Whether clays are absolutely barren, and not likely to be materially improved by cultivation, or whether they contain the necessary elements of fertility in an unavailable state, and are

[1] Rissler, "Geologie Agricole."

capable of being made better by ploughing, exposing to atmosphere, etc.

5. Whether or not land will be improved by liming.

6. Whether it is better to apply lime, or marl, or clay to a particular soil.

7. Whether special manures, such as superphosphate, can be used without injury to a particular soil, or whether the farmer should depend rather upon farmyard manure.

8. What kinds of artificial manures are best suited to certain soils.

A chemical analysis of the soil would give the percentages of the following substances contained in it :—

Potash (K_2O), soda (Na_2O), magnesia (MgO), lime (CaO), alumina (Al_2O_3), silica (SiO_2), ferric oxide (Fe_2O_3), ferrous oxide (FeO), carbon dioxide (CO_2), sulphuric anhydride (SO_3), phosphoric pentoxide (P_2O_5), Nitrogen (N), chlorine (Cl), and organic matter.

It must not be supposed that these substances exist in the soil in the state indicated above, or as elements. They form in the earth a variety of combinations. For instance, lime (CaO) might exist as—

Carbonate $CaCO_3 = CaO + CO_2$ (carbon dioxide),
Or as phosphate $Ca_3P_2O_8 = 3\,(CaO) + P_2O_5$ (phosphorus pentoxide),
Or as sulphate $CaSO_4 = CaO + SO_3$ (sulphuric anhydride).

and further instances involving other compounds might be given.

It would, however, be a difficult, if not altogether impossible matter to find out the amount of each compound existing in the soil, and so the difficulty is surmounted by expressing the total potash, lime, magnesia, sulphuric acid, etc., each separately. We get so accustomed to read and speak of the nitrogen, the phosphoric acid, the potash, etc., in the soil that, even amongst fairly advanced students, it is not at all an uncommon thing to find some who still have the idea that they exist in the soil actually in that form; and we have frequently come across students who, having read or heard of nitrogen, chlorine, etc., being taken in by the roots of plants, and having also read elsewhere that nitrogen and chlorine were gases, held the idea that these were taken up by the roots in the gaseous form.

Let it be understood at the outset that, when the nitrogen, etc., of the soil is spoken of, and when a plant is spoken of as taking up certain elements by its roots, these are not taken up in the *elementary form.*

Silica is a most abundant substance, existing in some soils,

e.g. sands, in very large quantities. By far the greater proportion, in fact almost the whole, is insoluble, and it has little use except to increase the bulk of the soil. It is taken up in the form of silicates by cereals in considerable quantities, and found in the straw; but it has been proved that it is by no means indispensable to these plants, and is simply a waste product.

Alumina is found as hydrated silicate of alumina (clay), and in a variety of other combinations. It is not in itself a plant-food, but it has important functions to perform in the soil, reference to which will be made in a later chapter.

Lime is found in most soils, often as carbonate; but also in other forms, as has already been indicated. Its percentage is variable, being over fifty per cent. in some chalks, and less than one per cent. in some sands. In addition to its value as a plant-food, this substance, both by its chemical and physical properties, is of great value in the soil.

Potash is one of the most important constituents of the soil, especially for certain plants, *e.g.* potatoes. It is found most abundantly in clays, owing to the fact that it is contained in considerable quantity in the felspar, from which the clay is derived. Sometimes from two to three per cent. is found in soils, but this is exceptional. A fair average is about 0·5 per cent., while poor sands often contain no more than 0·1 per cent.

Soda.—This, in its chemical properties, and in the compounds which it forms, is exceedingly like potash, but it cannot take its place in the soil; indeed, as a plant-food it is quite unimportant. It may exist as nitrate or sulphate, but most commonly as chloride, and where an excess of the latter salt is found it causes barrenness.

Iron exists in the form of ferric and ferrous oxides, and also as carbonate and sulphate.

Broadly speaking, the ferrous compounds are injurious to plant life, while ferric compounds are not merely harmless, but are very valuable plant-foods.

The reason for this difference is said to be the relative solubility of the two classes, the more soluble ferrous salts being more injurious than the less soluble ferric salts.

This, however, scarcely seems sufficient reason, and it would appear that the lower oxide, by reason of its greater affinity for other substances, interferes with the processes taking place in the plant, and thus acts as a poison. The presence of a considerable quantity of a ferrous compound therefore causes barrenness.

The late Dr. Voelcker held the idea that, owing to the affinity of ferrous compounds for oxygen, a large quantity of those compounds existing in the soil caused a scarcity of that gas, and thus injured the plants.

The colours of clay and other soils are very often due to iron; the lower oxide (ferrous) giving the blue colour, and the higher oxide (ferric) being responsible for brown and red. This difference in colour between the two oxides is exemplified by the change which takes place when a blue-coloured clay is exposed to the air. The exposure results in the oxidation of the ferrous oxide to ferric oxide, and the blue colour is changed to red.

Carbonic acid forms carbonates, the chief of which, as mentioned above, is carbonate of lime. Since plants get all their carbon from the air this is of little importance.

Sulphuric acid exists as sulphates, such as gypsum. These sulphates are the source of the sulphur of the protoplasm in the plants.

Phosphoric acid is one of the most important of the constituents of the soil, as it is indispensable to the growth of plants, and it is also usually found in very small quantities. It exists as phosphates, of which calcium phosphate is the commonest.

The usual percentage of this compound is about 0·1 to 0·2 per cent.

Chlorine exists as chlorides, but is of little importance.

Nitrogen is, perhaps, the most important of the constituents of the soil, and the one which is most frequently added. It is found as nitrates, as ammonia salts, and in organic matter; and it is the presence of this substance in humus which makes it valuable from a chemical point of view. The percentage in the soil is small, but the amount per acre is considerable.

Much, however, of the absolute nitrogen per acre is in a form which precludes its use by the plant until it has undergone certain changes, which will be referred to subsequently.

Magnesia is found in most soils, and exists in considerable quantity in those overlying the magnesian limestone. It is a plant-food, but not required in large quantity.

There are other constituents of soils which have not been mentioned, but which are of such little importance that it is hardly necessary to refer to them.

It may be mentioned, in talking about the composition of soils, that the absolute quantity of any constituent in a soil gives no idea as to how much is directly available for use by the plant. Only those portions which are soluble in water, or, perhaps, very dilute acid, are really at once available. The presence, however, of large quantities of plant food, even in an insoluble form, is an indication that the various operations of tillage will have an exceedingly good effect on the soil in question.

We give three examples of soil analysis—a clay, a loam, and a sand—which should be carefully compared.

Soil.	Insol. silicates and sand.	Lime.	Magnesia.	Alumina.	Potash.	Soda.	Ferric oxide.	Carbonic acid.	Sulphuric acid.	Phosphoric acid.	Chlorine.	Organic matter and water.[1]
Sandy	92·52	0·24	0·70	2·69	0·12	0·02	3·12		trace	0·07	trace	0·49
Loamy	81·26	1·28	1·12	3·58	0·80	1·20	3·41	0·92	0·09	0·38	trace	5·96
Clay	63·44	0·83	1·02	14·04	2·8	1·44	4·87		0·09	0·24	0·01	11·25

[1] Containing nitrogen.

Taking the weight of soil per acre at about three million pounds, the approximate amounts per acre of the various constituents can be worked out.

The Absorptive and Retentive Power of the Soil.

Closely connected with the composition of the soil is its absorptive and also retentive power, powers which are no longer supposed to be merely the result of a certain mechanical state, such as the spongy nature of humus and the impervious nature of clay.

The two powers are very nearly allied; indeed, they depend in a great measure upon the same properties.

If a solution of a soluble manure, *e.g.* sulphate of ammonia or superphosphate, be poured upon a considerable bulk of a fertile soil, a great deal of the manure will be retained, and the water filtering through will contain much less of the salt than it originally did, though it may contain other substances which were not before in it.

The reason of this absorption is stated to be that the substances are precipitated in a more or less insoluble form in the soil, and thus retained.

The actual changes which do take place are still, to a great extent, obscure; but the agencies taking part in them are hydrated ferric and alumina oxides, hydrous silicate of alumina, carbonate of lime, and humus. The hydrated ferric oxide is principally engaged in fixing phosphoric acid, for which it has a great affinity, and with which it forms insoluble basic ferric phosphate. This reaction takes place after the application of any soluble phosphate.

Hydrated oxide of alumina has a similar action, but is not so powerful as the corresponding iron compound. The hydrous silicate of alumina fixes potash and ammonia, and it was on the effect of these compounds that the theory of double silicates and their action in the soil was founded. By many now the

theory is disbelieved, but the adverse evidence is by no means conclusive, and, though the actions may not be precisely similar to what was stated by Professor Way, it is more than probable that interchange of bases takes place in a somewhat similar manner. Humus is said to have the faculty of absorbing ammonia or nitrogen from the air, but this is owing to the action of bacteria. One of the chief, however, of the substances which help to retain the various manures is carbonate of lime, and to this can be traced much of the benefit derived from applications of that substance. It acts alike upon potash and ammonia salts, combining with the acid and setting the alkali free to enter into other combinations in the soil.

Dr. Voelcker, in experimenting, found that when a solution of sulphate of ammonia was poured through a soil containing lime, the lime came through with the water, combined with the sulphuric acid, and the ammonia was retained.

$$(NH_4)_2SO_4 + CaCO_3 = CaSO_4 + (NH_4)_2CO_3.$$

It also fixed superphosphate by forming ordinary tri-calcic phosphate; and it likewise neutralizes any acidity of the superphosphate. It may be asked, "What is the use of applying manures in the soluble form, if they are retained by being made insoluble?" And, indeed, there seems good reason for the question. Experiments and actual practice have, however, shown the benefit of applying soluble manure; and our own idea is that, when a manure is added in a soluble condition, it is precipitated in so fine a form, and becomes so thoroughly incorporated with the soil, that it comes into close and complete contact with the root hairs. In this position it is acted on by the slightly acid exudation from the root, and taken up as required. (Also see p. 64.)

The process of retention is that which prevents subsequent washings by water from removing the absorbed matter. The power of retention is dependent upon the same physical and chemical conditions as absorption.

Of the value of these properties there can be no doubt, especially when we take into consideration the fact that, in addition to the manures added by the farmer, the soil is enriched by matter brought down by every shower of rain.

Thus the annual amount of nitrogen brought down by rain is about 4·4 lbs. per acre, and this comes down as ammonia 2·4 lbs., nitrates 1 lb., and organic nitrogen 1 lb; and, in addition to this, considerable quantities of chlorides and sulphates are brought down in similar manner.

Chemical Changes taking Place in the Soil, and the Influence of Various Tillage Operations on those Changes.

Weathering.—The process of weathering of soils is much the same as that of weathering of rocks, and is dependent upon the same agencies, viz. oxygen, carbonic acid, or carbon dioxide, and water.

Indeed, it may be looked on as a further stage in the same process. In the weathering of rocks highly complex compounds are broken down into simple ones, and large masses are pulverized; and in the weathering of soils these are still further acted on: insoluble compounds are changed into soluble ones, and thus into plant-food, and fragments are further pulverized; in addition to which, injurious matters are rendered harmless.

The oxygen is ever ready to convert lower oxides into higher; to act on the components of complex compounds, and thus break them down; and in this it is aided by the carbon dioxide, which readily forms carbonates.

Water acts principally as a solvent, especially when containing carbon dioxide in solution; and it must be remembered that even so-called insoluble substances, especially when in a finely divided condition, are readily dissolved in small quantity by water, and this may in some measure help to explain the use of adding soluble manures in preference to insoluble ones. Water, however, exerts another and purely chemical action, in that it unites with various substances, or, in other words, hydrates them. Thus with quicklime (CaO) it forms hydrated or slaked lime (CaH_2O_2), and forms pure clay, hydrated silicate of alumina, by uniting with aluminic silicate, as already noticed. These, acting in conjunction with physical agencies, bring about the reduction and pulverization of the soil, and help to increase the amount of available plant-food.

Nitrification.—Nitrogen in organic combination, or as ammonia, is not strictly available for plant food, but must undergo oxidation into nitrates before it becomes of use. A method for the production of nitre artificially from nitrogenous organic matter has been carried on for a considerable time, but it is only of late that the process of nitrification has come to be at all perfectly understood. It was first suggested by Pasteur that nitrification was brought about by a living organism, and this was subsequently proved to be the case by Schlöesing and Müntz, who showed that it could only live under satisfactory conditions, and that its functions were destroyed by high temperature and poisons, just as

were the functions of other organisms of the class to which it was supposed to belong.

Lately an organism, having in a high degree the power of nitrifying ammoniacal solutions, was isolated by Frankland, and Winogradsky afterwards succeeded in cultivating it, and was able to study it more thoroughly. It would seem, however, that the complete process of nitrification as carried out in the soil is not the work of one organism, but of several, a different class of organisms completing each different stage of the process; and it is worthy of note that, where nitrification has been carried out for experimental purposes, the necessary organisms have been supplied by adding soil, which would, of course, contain the various classes or families necessary. It may also be noted that the organisms *isolated* by Frankland and by Winogradsky, acting on an ammoniacal solution, produced not *nitric* but *nitrous* acid, which would lead to the conclusion that another species is necessary to complete the process.

The nitrogenous organic matter undergoes decomposition, one of the results of which is that compounds of ammonia are formed, and these by the process of nitrification are converted first into nitric acid, and then into nitrates. As to whether the whole process is carried on by bacteria, or only the latter part, is as yet a matter of uncertainty.

The researches of the scientists already mentioned, coupled with the experiments of Warington and other eminent chemists, have entirely exploded the old idea that the oxidation was due to a supposed property of the soil, of condensing in its pores the oxygen of the atmosphere, and have proved conclusively that bacteria alone can carry on the process of nitrification, and then only under suitable conditions.

It has also been shown that all nitrogenous organic matter, and probably also ammonia salts, must undergo this change before they are of use to the plant.

The necessity for this explains the slower action of ammonia manures as compared with nitrate of soda.

The favourable conditions mentioned are :—

(1) *The presence of oxygen.* If there be a scarcity of this, they cannot perform their work; indeed, cannot live. The nitrates may be looked on as a by-product of their life's work, and absence of oxygen, of course, stops this.

Here the value of tillage, etc., which admit the atmosphere to the soil, becomes again apparent.

(2) *The presence of moisture.* Bacteria can only live in a moist soil, the water being an actual necessity for their existence.

(3) *A favourable temperature.* From 40° to 130° Fahr. nitrification will be effected, but the best temperature is 98° Fahr. The period during which nitrification is carried on to the greatest extent is during the summer months—say from April or May up to September or October,—and during the other months it is practically at a standstill. This is a very important provision of nature, which guards against a loss of nitrogen by drainage during that part of the year when the ground is not covered by a crop, and provides for the greatest production of nitrates when vegetation is in its most vigorous state.

(4) *The presence of an alkaline base.* In order that the process may proceed most rapidly and effectively, some base, lime perhaps being the best, must be present, to neutralize the nitric acid as it is formed. The union results in nitrate of calcium, which is an exceedingly valuable plant-food.

Alkali, in excess even ammonia itself, is, however, fatal to the bacteria; hence it is not advisable to apply heavy urinary dressings, or excessive amounts of ammonia salts.

The addition of farmyard manure favours nitrification, not only because it contains considerable quantities of nitrogenous organic matter, but also because large numbers of bacteria are present in it.

The conditions which interfere with nitrification are generally the converse of those given above.

Where oxygen is deficient, the bacteria give rise to changes of a putrefactive nature, and cause the loss of nitrogenous matter, as nitrogen gas, oxides of nitrogen, and ammonia.

Water has been described as indispensable, but an excess of that substance is fatal to nitrification.

The presence of injurious substances, as gas-lime, ferrous sulphate, etc., has been found to stop it.

The amount of nitrogen produced by the above process naturally varies considerably under the varying conditions met with; but from experiments at Rothamsted on ordinary land under bare fallow (when maximum nitrification might be expected to take place), from 35 to 55 lbs. nitrogen as nitric acid was found at the end of the summer in the first 20 inches of the soil on an acre of land, and it was estimated that nitrates equal to 80 lbs. of nitrogen had been produced during the fifteen months the land was without a crop.

Tillage, by altering the mechanical condition of the soil, and by opening it up, encourages weathering, oxidation, nitrification, and, indeed, all the chemical changes taking place in the soil. It thus improves the condition of the soil, increases the amount of available plant-food, and generally acts as a substitute for manure,

especially if the soil be a good deep one, and with plenty of resource.

Drainage.—Like the above, drainage promotes the chemical changes, since it allows the oxygen of the air to have access to the interior of the soil; but the effect is much more marked in this case, for while land is water-logged, the helpful chemical changes are at a standstill. Oxidation cannot proceed, as the water effectually prevents the access of the air. Nitrification is prevented, and *de*nitrification is encouraged. Complex organic compounds of a more or less sour nature are formed, together with other substances which are injurious to plant life, such as ferrous oxide.

The removal of the superfluous water, however, by promoting a thoroughly healthy state of things, speedily rectifies all this, and the increase of useful grasses over useless ones, the gain in the yield of the crops, and the general improvement in the appearance of the land, show the benefits arising from judicious draining.

Clay-burning.—More information on this will be found in the chapter on Tillage. Briefly, the chemical effects are—

(1) Loss of nitrogen owing to combustion of the organic matter of the soil.

(2) The amount of soluble salts is increased owing to decomposition of silicates, etc., at the high temperature, which renders available potash, soda, and iron salts, and also of phosphates where they are associated with limestone, the complete decomposition increasing the amount of soluble phosphoric acid.

(3) Where the quantity of lime is small, the amount of soluble phosphoric acid is decreased.

Liming.—The effect of this operation depends greatly upon the state in which the lime is applied. It is applied in three forms—quicklime, or burnt-lime (CaO); slaked slime (CaH_2O_2); air-slaked lime, or carbonate ($CaCO_3$).

The first is the lime as it comes from the kiln.

The second, after being slaked, purposely or by rain falling on it.

The third, after standing exposed to the air for a considerable while.

The equations representing the changes taking place are—

$$(1)\quad \overset{\text{(Limestone.)}}{CaCO_3} + \overset{\text{(Coke or Coal used in kiln.)}}{C} = \overset{\text{(Quicklime.)}}{CaO} + \overset{\text{(Carbonic Oxide.)}}{2CO}.$$

$$(2)\quad \overset{\text{(Quicklime.)}}{CaO} + \overset{\text{(Water.)}}{H_2O} = \overset{\text{(Slaked Lime.)}}{CaH_2O_2}.$$

$$(3)\quad \overset{\text{(Quicklime.)}}{CaO} + \overset{\text{(Carbon Dioxide.)}}{CO_2} = \overset{\text{(Air-slaked Lime.)}}{CaCO_3}.$$

The first two are the most active and the most generally used.

Lime, in whatever form it be applied, acts as—

(1) A plant-food, some plants, *e.g.* clover, requiring a considerable quantity.

(2) A corrective of acidity, on, for instance, recently drained soils.

(3) An aid to the absorptive and retentive properties of the soil.

Applied as quicklime it has special functions.

(*a*) It increases the amount of plant-food in the soil by directly attacking the complex insoluble compounds, and breaking them down.

(*b*) It exercises a destructive action on organic matter which may be exceedingly injurious to the soil under certain circumstances, that is, where organic matter is deficient, the result of the decomposition being ammonia, carbon dioxide, and water.

(*c*) It at once corrects the sourness of a soil by combining with the organic acids.

As slaked lime, the effects are much the same, though perhaps not so vigorous.

As carbonate of lime, the effects are much less marked, though it may be noticed that, in the case of quicklime and slaked lime, the greater portion very soon forms carbonate of lime in the soil by uniting with carbon dioxide. It acts—

(*a*) As a plant-food, being fairly soluble, especially when in so fine a state as it is if formed by the action of the carbon dioxide of the air on quicklime.

(*b*) It acts as an important aid to nitrification (*vide* nitrification, pp. 64–66)—a process to which quicklime and slaked lime as such are injurious.

B.—*Chemistry of Manures.*

Manures.

As plants take a considerable portion of their food from the soil it follows that if the whole or part of a crop be removed from a field, the land becomes impoverished. That such is the case has been proved on a large scale in the huge corn-fields of America, where land which at first yielded enormous crops, after being cropped continually year after year for some time, would not give a sufficient yield to pay. In other words, the land had become "exhausted."

According to Warington, average crops of wheat, oats, barley, and swedes would contain respectively :—

	Nitrogen.	Sulphur.	Potash.	Soda.	Lime.	Magnesia.	Phosphoric Acid.	Chlorine.	Silica.
Wheat : grain	33	2·7	9·3	0·6	1·0	3·6	14·2	0·1	0·6
,, straw	15	5·1	19·5	2·0	8·2	3·5	6·9	2·4	96·3
	48	7·8	28·8	2·6	9·2	7·1	21·1	2·5	96·9
Oats : grain	38	3·2	9·1	0·8	1·8	3·6	13·0	0·5	19·9
,, straw	17	4·8	37·0	4·6	9·8	5·1	6·4	6·1	65·4
	55	8·0	46·1	5·4	11·6	8·7	19·4	6·6	85·3
Barley : grain	35	2·9	9·8	1·1	1·2	4·0	16·0	0·5	11·8
,, straw	13	3·2	25·9	3·9	8·0	2·9	4·7	3·6	56·8
	48	6·1	35·7	5·0	9·2	6·9	20·7	4·1	68·6
Swedes : root	74	14·6	63·3	22·8	19·7	6·8	16·9	6·8	3·1
,, tops	28	3·2	16·4	9·2	22·7	2·4	4·8	8·3	3·6
	102	17·8	79·7	32·0	42·4	9·2	21·7	15·1	6·7

The figures represent the number of pounds of the respective substances, and the weights of crops taken are—

Wheat, 30 bush. @ 60 lbs. =	1800
Straw	3158
	4958
Oats, 45 bush. @ 42 lbs. =	1890
Straw	2835
	4725
Barley, 40 bush. @ 54 lbs. =	2080
Straw	2447
	4527
Swedes: roots, 14 tons =	31,360
,, tops	4704
	36,064

From the typical examples taken, it will be seen that, though the crops exhibit considerable differences in the respective amounts

of the various substances which they contain, yet all have made very large demands upon the plant-food contained in the soil.

This does not, however, represent the total loss, as an appreciable quantity of soluble matter is washed out with the drainings of the soil.

These losses have to be made good in some way, and there are two or three courses by which this may to a greater or less extent be accomplished. The farmer may, by extensive and careful tillage, develop the natural resources of the soil; he may introduce a carefully arranged rotation of crops; or he may restore the lost matters by the direct application of fresh supplies. A substance thus added to restore the fertility or increase it is a *manure.*

We have said that one of three courses may be pursued: but in practice the three are always worked together; as, however carefully arranged a rotation might be, the crops reared would never be satisfactory, under existing circumstances, if no manures were applied; and many soils have in themselves but little resource to develop by tillage.

Since manuring is but the return to the land of what has been taken from it, it would seem, knowing the composition of the crop removed, to be a very simple matter. This, however, is not so, as there are a great many considerations to be taken into account if manuring would be successful and economical, as it ought to be.

No farmer, for instance, would think of adding, unless in exceptional circumstances, soda, magnesia, silica, or chlorine as manures, these substances being contained in sufficient quantity in almost all soils. Then, again, the nature and composition of the soil has to be taken into consideration. Thus clays derived from potash felspar would not need potash manuring, while many sandy soils would, on the contrary, be highly benefited thereby. Also, it would hardly be necessary to add lime to a chalky soil.

In addition to the above, the nature of the crop exercises a great influence on the manuring.

A reference to the table will show that an average crop of swedes will remove more than twice as much nitrogen as an average wheat crop, and yet the wheat is much more dependent upon nitrogenous manures than swedes. Similarly the two crops remove nearly equal quantities of phosphoric acid; but a phosphatic manure is much more essential for the swedes than for the wheat.

The deep-rooted wheat seems to have a much greater ability to assimilate the phosphates of the soil—largely, no doubt, on account of the root range—than the shallower-rooted swede.

The difference in the power of assimilating nitrogen is stated by Warington to be chiefly due to the fact that the period of most vigorous growth of the swede is likewise the period of the year when nitrification is most active; while during that portion of the year that the wheat most requires nitrogen, nitrification is at a standstill.

Similarly, it will be found that all crops are influenced in a greater degree by one special ingredient than by the remainder. Thus the—

Cereals require nitrogenous manures.			
Turnips and swedes require	phosphatic manures.		
Mangels	„	nitrogenous	„
Potatoes	„	potash	„

If we add to the above considerations the effect of climate on the effect of manures, we see that successful and economic manuring is by no means simple or easy of attainment.

No exact rules can be laid down, nor can any one say that such and such a manure is an infallibly good manure for a certain crop in all places; nor does it follow that because a manure gave good results with one farmer, that it will equally please another.

Each farmer must test for himself the effect of certain manures or combinations of manures on the crops he grows; indeed, that is what every successful farmer does. But there is no need to try only one manure in a year. By marking off a portion of one field, and dividing it into small plots, as many trials could be made in one year as are usually made in a dozen; and a couple of years would give the experimenter practically all the information he required as to the effect of the different manures on the various crops on his land. Such a systematic trial would be worth far more than another's highest recommendations; and if the farmer bought only pure, guaranteed manures, and did all the mixing himself, he would know exactly what was needed for each crop, and would not be helping to swell the enormous profits made on mixed manures.

The pure manures should be limited generally to nitrogenous, phosphatic, potassic manures, and also those containing lime. Below is a table by M. Ville, which, in the first column, gives the various crops; in the second, the manurial ingredient by which each is most influenced, and hence called the "dominant ingredient;" and, in the third column, the manures whose chief value depend upon the proportion of the respective ingredient which they contain :—

Crop.	Dominant Ingredient.	Manure.
Wheat Barley Oats Rye Grasses Beetroot	Nitrogen.	Ammonia sulphate. Nitrate of soda. Nitrate of potash.
Peas Beans Clover Tares Sainfoin Lucerne Potatoes Flax	Potash.	Kainit. Muriate of potash. Nitrate of potash. Purified potash. Sulphate of potash.
Turnips Swedes Maize Artichokes	Phosphates.	Bone manures. Bone black. Burnt bones. Superphosphates. Basic slag.

Apart from M. Ville's system, such a table has great value to any agriculturalist as a reference.

Taking the above as his guide, however, and having summarily disposed of farmyard manure as being in his eyes comparatively worthless, M. Ville has, by careful mixing, arranged suitable manures for all crops; the manuring being spread over the whole rotation, what are known as fractional dressings being given, the object of which is to have a regular supply of available food.

Classification of Manures.

Manures may be classed as General and Special Manures, or as Natural and Artificial. The former is the better arrangement, as the latter is purely arbitrary, the distinguishing feature of an "artificial" being that it has passed through the dealer's hands. Thus the naturally occurring guano is classed as an artificial manure, as are potash salts, even if they are applied just as obtained from the beds.

A General manure is one which contains all the constituents removed from the soil by crops, and consists generally of animal or vegetable matter in a more or less advanced state of decomposition. The commonest and best example of such a manure is farmyard manure, after which might be mentioned—excrementitious: guano, night-soil and poudrette, town sewage, native guano, human egesta, birds' dung, liquid manure, sheep's manure.

Other animal manures: chiefly refuse from fisheries, slaughter-houses, tanneries, glue-works, oil-works, refuse wool, hair, feathers, horn shavings, etc.

Vegetable manures: refuse cakes, green crop manures: composts, seaweed, bran, and brewer's grains.

Special manures usually contain in quantity only one constituent of plant-food. They may be mixed with each other before applying, or used separately, according to circumstances.

The term "special" is also used to denote a special-purpose manure, such as a turnip-manure, potato-manure, etc.—concoctions which, as a rule, are sold at prices infinitely higher than what they are worth.

General Manures.

Farmyard Manure. — This, the commonest and most important of the general manures, in spite of criticism still holds its own. It consists, of course, of the excrements of the various animals kept on the farm, with the litter supplied to the animals. Hence its composition will vary to some extent with the nature of the farm, the kind of stock kept, the food given, and the litter used. Greater variations, however, may be introduced by the management or mismanagement of the manure after production.

When the manure is stored in a heap it undergoes a species of fermentation, which is brought about by agency of organisms, the action of which, however, is but imperfectly understood. The conditions which are favourable to a rapid fermentation, and those which retard the fermentation, have, however, been carefully studied.

1. *The Composition of the Manure.*—This affects considerably the rapidity of the fermentation; the concentrated nitrogenous manure from the stable, for instance, fermenting much more rapidly than the watery voidings of the milch cattle. Indeed, so rapidly does the former ferment, that, if kept dry, sufficient heat will be developed during the fermentation to blacken and even fire it.

2. *The External Temperature.*—The activity of the organisms is dependent upon the temperature, so that the most rapid fermentation will take place in summer. The chemical changes taking place during the fermentation are themselves productive of a certain amount of heat, so that once the process is well started it becomes less dependent on the temperature of the surrounding atmosphere. The temperature of the heap should not be allowed to rise above 80° Fahr.

4. *The Supply of Air.*—Where the heap is loose, and the air has easy access to the interior, the fermentation proceeds rapidly; but where, from consolidation, the air cannot penetrate, the process is greatly retarded. It is held that where the air is

excluded in this way, fermentation can only go on up to a certain point, it being conducted by a class of organisms not requiring oxygen for their support. The fermentation is only complete in the presence of atmospheric oxygen, as the later stages are carried on by organisms, which are dependent upon oxygen for their existence.

5. *The Presence of Water.*—This has the effect of lowering the temperature, and hence decreasing the rate of fermentation, and it also contributes to the same result by preventing the access of air.

Seeing that so many conditions affect the fermentation, it should be under the direct control of the farmer, and, in order that this be so, the manure-heap should be provided with a light roof, a watertight floor, and the drainings should be conducted into a tank. Into this tank also the drainings from the cow-sheds, etc., ought to be conveyed; and a pump should be so fixed that, when necessary, the temperature of the heap may be lowered by pumping over it the liquid contained in the tank. With such an arrangement, and knowing the conditions affecting fermentation, the process can be regulated to a nicety; but where the manure-heap is exposed in the middle of the yard, alternately washed with a shower of rain, and then dessicated by the summer sun, not only is the fermentation out of control, but the most valuable portion of the heap is being lost.

The chemical changes taking place during fermentation are, no doubt, highly complex; but, as yet, the information concerning them is anything but complete.

The result is an increase of soluble matter, and also an increase in the amount of water.

Considerable quantities of CO_2 (carbon dioxide) are given off during the fermentation, as well as a fair proportion of marsh gas (CH_4)—a gas which may be observed rising in bubbles from decaying vegetable matter in stagnant water. It is the same gas which is found amongst the coal, and is there called "fire-damp." Small quantities of sulphuretted hydrogen (SH_2) and phosphoretted hydrogen (PH_3) also escape, together with some carbon disulphide (CS_2), resulting from the decomposition of the albuminoids. Where the heap gets unduly heated, considerable amounts of ammonia gas (NH_3) are given off, often in sufficient quantity for it to be recognized by its smell.

Most of the ammonia produced in this way is a product of the decomposition of urea and like bodies.

Urea undergoes a fermentation in urine, by which ammonium carbonate is produced, the change being brought about by a micrococcus, and the action represented by—

$$\underset{\text{Urea.}}{CO \lt^{NH_2}_{NH_2}} + \underset{\text{Water.}}{2OH_2} = \underset{\text{Ammonium Carbonate.}}{(NH_4)_2CO_3}$$

Under the influence of heat this decomposes into carbon dioxide, water, and ammonia gas.

$$\underset{\text{Ammonium Carbonate.}}{(NH_4)_2\,CO_3} = \underset{\text{Carbon Dioxide.}}{CO_2} + \underset{\text{Water.}}{OH_2} + \underset{\text{Ammonia Gas.}}{2NH_3}$$

Dr. Voelcker found that organic acids, such as ulmic and humic, were produced during the decomposition of the manure, and, where the temperature does not become too high, the ammonia of the ammonium carbonate combines with the ulmic and humic acids to form ammonium salts of those acids, which are not so easily decomposed as the carbonate.

These organic acids also combine with the potash and soda, producing exceedingly soluble salts, and the formation of these soluble compounds during the fermentation explains the great loss to which manure is liable when washed by rain.

(For Table giving the composition of fresh manure, and also thoroughly fermented manure, see next page.)

According to Warington, a ton of farmyard manure contains from—

9 to 15 lbs. nitrogen, equal to 57¼ to 96 lbs. nitrate of soda (95 per cent. pure).
9 to 15 lbs. potash, equal to 68 to 113½ lbs. kainit (containing 24·5 per cent. sulphate of potash).
4 to 9 lbs. phosphorus pentoxide, equal to 35 to 79 lbs. superphosphate (con taining 25 per cent. soluble phosphate).

From these figures we see the small amount of fertilizing ingredients which farmyard manure contains. M. Ville, who puts no great faith in this manure, says that the following mixture contains as much of the four great constituents of plant-food as sixteen tons of dung:—

	lbs.
Superphosphate of lime	520
Potassic chloride	282
Sulphate of ammonia	691
Sulphate of lime	747
	2240

Use of Ammonia Fixers.—In order to prevent the waste of ammonia by volatilization various substances are added to the manure, the object of which is to form compounds with the ammonia which shall not be liable to decomposition. Amongst

COMPOSITION OF FARMYARD MANURE.

	Long or Fresh Manure. 2 weeks old.		Well-rotted Manure, 6 months in heap.	
Water		66·17		75·42
Soluble organic matters[1] ..		2.48		3·71
Soluble inorganic matters—				
Silica	0·237		0·254	
Phosphate of lime	0·299		0·382	
Lime	0·066		0·117	
Magnesia	0·011		0·047	
Potash	0·573		0·446	
Soda	0·051		0·023	
Chloride of sodium	0·030		0·037	
Sulphuric acid	0·055		0·058	
Carbonic acid, and loss ..	0·218		0·106	
		1·54		1·47
Insoluble organic matters[2] ..		25·76		12·82
Insoluble inorganic matters—				
Silica	1·528		2·434	
Oxides of iron, alumina and phosphates	0·596		0·947	
Containing phosphoric acid ..	(0·178)		(0·274)	
Equal to bone earth ..	(0 386)		(0·573)	
Lime	1·120		1·667	
Magnesia	0·143		0·091	
Potash	0·099		0·045	
Soda	0·019		0·038	
Sulphuric acid	0·061		0·063	
Carbonic acid, and loss ..	0·484		1·295	
		4·05		6·58
		100·00		100·00

[1] Containing nitrogen	0·149	0·297
Equal to ammonia	0·181	0·360
[2] Containing nitrogen	0·494	0.309
Equal to ammonia	0·599	0·375
Total nitrogen	0·643	0·606
Equal to ammonia	0·780	0·735

the substances used for this purpose may be mentioned gypsum, iron sulphate (copperas), sulphate of magnesia, crude potash salts, and also sulphuric and hydrochloric acids in very dilute condition. There are also several preparations in the market for absorbing liquid manure, claiming also to fix the ammonia, the properties of which depend partly upon their absorbent nature, and partly upon the fact that they contain substances like the above-mentioned.

It will be observed that the first four of these substances are sulphates, and their action depends upon the fact that they form ammonia sulphate, which, besides being stable, is a valuable

plant-food. The equations representative of the respective reactions are—

With gypsum—

Ammonium Carbonate.		Gypsum.		Ammonium Sulphate.		Carbonate of Lime.
$(NH_4)_2CO_3$	+	$CaSO_4$	=	$(NH_4)_2SO_4$	+	$CaCO_3$

With ferrous sulphate (copperas)—

		Ferrous Sulphate.				Ferrous Carbonate.
$(NH_4)_2CO_3$	+	$FeSO_4$	=	$(NH_4)_2SO_4$	+	$FeCO_3$

With sulphate of magnesia—

		Sulphate of Magnesia.				Carbonate of Magnesia.
$(NH_4)_2CO_3$	+	$MgSO_4$	=	$(NH_4)_2SO_4$	+	$MgCO_3$

Crude potash salts contain sulphate of potash.

		Sulphate of Potash.				Carbonate of Potash.
$(NH_4)_2CO_3$	+	K_2SO_4	=	$(NH_4)_2SO$	+	K_2CO_3

The use of dilute acids is not very extensive, though they have found some little favour when mixed with sand. They form chloride and sulphate of ammonia.

		Hydrochloric Acid.		Ammonium Chloride.		Water.		Carbon Dioxide.
$(NH_4)_2CO_3$	+	$2HCl$	=	$2NH_4Cl$	+	OH_2	+	CO_2
		Sulphuric Acid.						
$(NH_4)_2CO_3$	+	H_2SO_4	=	$(NH_4)_2SO_4$	+	OH_2	+	CO_2

The Value of Farmyard Manure.—Lately this manure has been subjected to a great deal of criticism, and many chemists have sought to prove that it is the most expensive and wasteful of all the manures used. The small quantity of available fertilizing matter contained in it has given rise to this; and if it be looked at from this point of view only, the opinion would appear to be well founded.

The cost of cartage and distribution is great, especially if the district be hilly and the fields be at some distance from the midden. Indeed, this item may be so heavy in certain districts as to preclude its use, except upon the fields very near at hand.

There are, however, many circumstances which render farm-yard manure a very valuable commodity, a safe fertilizer in any hands, and certain in its results.

(1) It contains all the constituents removed by the crop from the soil. Some parts of the crop have been passed through the

bodies of animals; other parts have simply undergone decomposition, *e.g.* straw. That which has passed through the animals has been robbed, to some extent, of phosphates and nitrogen. A considerable portion of the nitrogen is passed off as urine, and thus finds its way into the manure.

Since, however, part of these substances is retained by the animals, and the loss during fermentation, etc., is considerable, this manure does not contain all the constituents required by the crops, in sufficient amount to supply the demands—that is, unless an excessive quantity of the manure is used. Hence this manure is commonly used in company with artificials.

(2) Farmyard manure usually contains a large number of nitrifying bacteria, and also a considerable quantity of nitrogenous organic matter upon which the bacteria can act.

(3) It contains a large quantity of organic matter which has a highly beneficial effect on many soils, especially those deficient in humus.

The effect is seen when fresh or green manure is added to a heavy clay soil, as the stiff clay is mellowed and rendered freer to work and in every way a more desirable soil.

On light lands it is always applied in a thoroughly rotten—short—condition, and, if possible, at a time when the plant will speedily be able to make good use of the material.

(4) Its effect is felt for a long time after it is applied.

Much of the matter of which it is composed is insoluble when it is added, but it gradually changes its nature, owing to nitrification and other actions. The continuous supply of plant-food thus prepared is at once used up, and the insoluble residue has no tendency to be washed out of the soil. In winter, when the land is not under a crop, nitrification is at a standstill, and this prevents loss of plant-food during those months.

This permanence of effect is one of the most valuable characteristics of farmyard manure, as if applied once in a rotation, it benefits all the crops in that rotation.

Its influence has been distinctly traced so far as twenty years after application, and Sir J. B. Lawes estimates the period through which it will act as considerably longer than this.

(5) By its decomposition in the soil it sets free carbonic and other acids, and helps in the formation of other plant-foods.

(6) It is a universal manure, suiting all crops, climates, and soils. In the case of leguminous crops, where great difficulty has been experienced in arranging satisfactory artificial mixtures, farmyard manure has always given excellent results.

In many parts of England it is the only manure used, as, owing to the climate, the artificials cannot be depended on; and

this is more marked in the case of some of the countries of southern Europe, in whose dry climate dung is the only satisfactory manure.

(7) It is one of the products of the farm, and must be consumed in some way; and even granting it a low value, the best, cheapest, and easiest method of disposing of it is to apply it directly to the land.

Guano.—This substance, which consists chiefly of the accumulated excrements of seabirds, depends for its value upon the amount of nitrogen, phosphoric acid, and potash it contains.

The first samples, coming from the rainless islands of Peru, contained the largest proportion of nitrogen, existing as urates and salts of ammonium.

Many of these samples contained nitrogen equal to twenty per cent. of ammonia; but these supplies are no longer available, having been worked out. A good sample to-day would contain about eight to twelve per cent. of ammonia.

In such guanos the amount of phosphates is comparatively small—say about thirty per cent.—and the potash equals about three to five per cent.

The greater proportion of the guano imported at the present day belongs to the class of phosphatic guanos. These deposits have been exposed to rain until the highly soluble compounds have been washed out, leaving the more insoluble matters—chiefly tricalcic phosphate—behind.

The amount of phosphate varies from thirty to eighty per cent., and the amount of nitrogen is equal to three to five per cent. of ammonia.

The subjoined table gives the composition of some typical guanos.

COMPOSITION OF GUANOS.

	NITROGENOUS.			PHOSPHATIC.		
	Chincha Islands.	Ichaboe.	Angamos.	Mejillones.	Curaçao.	Patagonian.
Water	13·67	18·60	8·76	8·98	11·53	23·00
Organic matter, etc.	52·05	47·84	69·96	8·36	7·11	26·50
(yielding ammonia)	(16·52)	(13·00)	(23·44)	(0·75)	(traces)	(4·10)
Calcic phosphate ..	22·78	10·86	12·07 (phosphate and carbonate)	71·16	72·84	40·54
Calcic carbonate ..	..	3·44		4·30	8·32 (carbonate and alkaline salts)	2·00
Alkaline salts ..	9·67	10·90	8·27	3·34		5·66
(containing potash)	..	(2·00)	(2·10)	(2·00)	(0·50)	(1·30)
Insoluble matter ..	1·83	8·36	0·94	3·86	0·20	2·30
	100·00	100·00	100·00	100·00	100·00	100·00

Some of the phosphatic guanos are now treated with sulphuric acid, by which a great portion of the tricalcic phosphate is rendered soluble. Guanos so treated are known as dissolved guanos.

Seeing the composition varies so much, it is always necessary to get a guaranteed analysis before purchase. The unit value is then easily worked out.

Guanos have often been adulterated with sand, clay, powdered limestone and bricks, salt, gypsum, etc. Various simple tests can be readily made to prove the genuineness.

(1) The *colour* should be that of coffee and milk: if very brown, it contains too much water; if grey, it is too earthy.

(2) The *smell* should be ammoniacal, and strongly so when damp. The guanos imported long ago, such as the Chincha Island, had a very powerful odour, and many farmers still prefer a strong-smelling artificial manure.

(3) The *taste* is strong—salt and caustic.

(4) The *consistency*. Oily to the touch. Usually found in small grains. When the pieces appear crystallized on breaking, the manure is usually rich in urates, and consequently in nitrogen.

(5) The *flame*. It will readily blaze up if good, and leave a considerable residue of ashes. This shows whether it is rich in organic matter or not.

(6) The *ash* ought to be perfectly white. When reddish-brown, the guano may have been adulterated with powdered bricks, marl, clay, sand, etc. The ash should dissolve completely in hydrochloric acid, without effervescence. An insoluble residue indicates adulteration; effervescence shows the presence of large amounts of carbonate of lime.

(7) When mixed with quicklime, there ought to be a strong evolution of ammonia.

(8) The weight per bushel is from sixty-eight to seventy pounds. When adulterated it is usually lighter.

Poudrette contains from 14·8 to 37·4 per cent. organic matter (giving 0·95 to 2·5 per cent. nitrogen), 0.87 to 3 per cent. phosphoric acid, 0·6 to 1·5 per cent. potash, and 1 to 6·7 per cent. lime. It is consequently not very rich in fertilizing ingredients.

Native guano consists of the precipitated solids of sewage water. The reagents used for this purpose are numerous, but those most generally employed are alum, blood, and clay, in what is known as the A B C process. The mixture is dried and then sold. The following table gives the composition of two samples :—

	I.	II.
Water	6·12	7·91
Organic matter[1]	22·45	19·40
Phosphate of lime	2·81	2·40
Carbonate of lime	6·37	20·93
Alkalies and magnesia	3·56	2·92
Iron oxide and alumina	6·59	8·78
Clay and sand	52·10	37·66
	100·00	100·00
[1] Containing nitrogen	1·92	0·96
equal to ammonia	2·23	1·16

Rendonda and Alta Vela phosphates (containing a large percentage of alum) have been used for this purpose of clarification.

Human Egesta.—The following analyses of human excrements are by Griffiths :—

	I. Solid.	II. Liquid.
Water	75·00	97·00
Organic matter[1]	22·13	2·02
Iron oxide	0·13	..
Lime	0·43	0·02
Magnesia	0·38	0·01
Phosphoric acid	1·07	0·04
Sulphuric acid	0·06	..
Potash	0·30	0·05
Soda	0·08	} 0·86
Sodium chloride	005	
Insoluble matter	0·37	traces
	100·00	100·00
[1] Containing nitrogen	1·50	0·58
equal to ammonia	1·82	0·71

Nightsoil.—The analyses show that the substance is not of very high value.

The following are by Dr. Voelcker :—

	I. Earth before use.	II. Earth once used.	III. Earth twice used.	IV. Earth thrice used.
Moisture	10·00	21·69	11·81	13·81
Organic matter and water of combination [1] ..	8·89	7·67	10·17	10·53
Iron oxide and alumina ..	11·65	12·65	12·43	10·76
Phosphoric acid	1·62	0·19	0·39	0·44
Calcium carbonate ..	1·75	1·76	1·88	1·84
Magnesia	1·30	2·06	0·68	0·78
Alkaline salts			0·64	0·64
Sand and clay	64·79	53·98	62·00	61·20
	100·00	100·00	100·00	100·00
[1] Containing nitrogen	0·31	0·37	0·42	0·51
equal to ammonia	0·37	0·45	0·51	0·62

Liquid Manures generally consist of the urine of farm-stock, with the drainings from the dung-heap. The urine of the different animals varies greatly in character.[1] That of the *horse* is cloudy, and has an alkaline reaction. Its specific gravity is 1·05. It becomes brown on exposure to the air, and deposits carbonate of lime. From $\frac{1}{3}$ to $\frac{1}{2}$ of the calcium salts of the food, and up to $\frac{2}{3}$ of the potassium compounds appear in the urine. The urine of the *ox* is clear yellowish, or greenish, and possesses a peculiar musky odour. It has a specific gravity of 1·02 to 1·03. The urine of the *sheep* is similar to that of the ox, but the amount of solids it contains varies more and is usually less. Its specific gravity runs from 1·006 to 1·015. The urine of the *pig* is clear,

[1] Composition of Urine.

	I. Horse.	II. Ox.	III. Pig.
Water and undetermined substances ..	91·00	92·13	97·91
Urea	3·10	1·85	·49
Alkaline lactates	2·01	1·72	—
Potassium hippurates	·47	1·65	—
Potassium bicarbonate	1·55	1·61	1·07
Potassium sulphate	·12	·36	·20
Magnesium carbonate	·42	·47	·09
Calcium carbonate	1·08	·06	traces
Sodium chloride	·07	·15	·13
Phosphates	—	—	·10
Silica	·10	traces	·01
	99·92	100·00	100·00

yellowish, with an alkaline reaction; specific gravity, 1·010 to 1·015. It contains urea, but rarely uric or hippuric acids. The average amount of urine voided annually by the horse is 4380 lbs., by the ox 20,000 lbs., by the sheep 380 lbs., and by the pig 1200 lbs.

The drainings from the dung-heap, with which the urine mixes, have the following average composition, according to Wolff:—

Water	98·20
Organic matter	0·70
Ash ingredients	1·10
	100·00
Nitrogen	0·15
Potash	0·49
Phosphoric acid	0·01
Lime	0·03
Magnesia	0·04

During the time liquid manure is usually stored, fermentation proceeds, and the organic forms of nitrogen (urea, etc.) are decomposed with the production of ammonia. A small amount of very dilute sulphuric acid is sometimes added to fix this latter compound.

Sheep-fold Manure gives back to the soil, with the least waste, the constituents taken from it by crops, and afterwards used as food by the stock. Should cake or corn and hay be supplied as well, the soil is fully compensated for the slight loss occasioned by the growth of the animals and their production of wool and mutton.

ANALYSIS OF SHEEP MANURE.

Water	69·30
Dry organic matter	23·71
Ash ingredients	6·99
	100·00
Potash	0·77
Lime	0·60
Magnesia	0·06
Phosphoric acid	0·21
Ammonia	0·45
Total nitrogen	0·61

Other Animal Manures.—*Fishery Refuse* consists of whole fish and offal, and is preferably used in a compost, at the rate of say 1½ tons per acre. It contains about 1¾ per cent. nitrogen and 1 per cent. of phosphoric acid, and is suitable for cereals and root crops.

Fish Guano is somewhat of the same nature, consisting of refuse from fish-curing yards, and from Norway cod-oil factories. This material is dried and ground up.

Most of the manure obtained from Norway has had salts of potash and magnesia added as preservatives, an addition which considerably enhances its value, as otherwise the manure is somewhat poor in potash.

Such a manure naturally varies considerably in composition. A good sample of the Norwegian "potash" guano may contain 10 to 12 per cent. ammonia, 18 to 30 per cent. phosphates, and from 8 to 15 per cent. sulphate of potash. The less valuable forms contain up to 8 per cent. of ammonia and 40 per cent. phosphates.

Broad-casted, say a fortnight before sowing the seed, these manures have given excellent results with a large number of crops, the rate of application being from 3 to 6 cwts. per acre.

As a rule the manure contains a large proportion of oil, the presence of which interferes considerably with the decomposition, and this renders it very slow in its action. The lower the percentage of oil, other things being equal, the more valuable the manure.

Slaughterhouse Refuse is rich in nitrogenous organic matter. Made into a compost with road-scrapings and *old* mortar or *old* lime, it forms a valuable manure, owing to the formation of nitre in the heap.

Tanyard Waste contains about $1\frac{1}{2}$ per cent. nitrogen, $2\frac{1}{2}$ per cent. tricalcic phosphate, and 13 per cent. lime.

It has little value as a manure, and spent bark practically has none at all. *Glue Refuse* contains about $2\frac{1}{2}$ per cent. nitrogen.

Refuse Hair, Feathers, etc., contain some quantity of nitrogen, feather and fur waste averaging about $6\frac{1}{2}$ to $8\frac{1}{2}$ per cent.

Wool Refuse and Shoddy depend for their value upon the percentage of nitrogen. They are, however, very insoluble, and unless treated with superheated steam or sulphuric acid are not of great value. In wool waste there is about 5 per cent. nitrogen; in shoddy about 7 to 13 per cent.

The latter is largely used as a manure for hops.

Horn Dust, keronikin, yields about 16 to 18 per cent. of ammonia, but is of little value unless exceedingly finely divided.

Leather contains from $4\frac{1}{2}$ to 9 per cent. of ammonia.

Frey-Bentos Guano is the residual waste matter from the manufacture of extract of meat, after it has been dried and finely ground.

It contains from 5 to 14 per cent. of ammonia, and 5 to 35 per cent. phosphates.

Meat Meal is a manure of similar composition, containing more ammonia and less phosphates.

Manchester Manure is made from waste organic matter, and contains about 3·7 per cent. ammonia, 8 per cent. phosphates, 2·8 per cent. alkaline salts, and 15 per cent. sulphate and carbonate of lime.

These refuse manures are, as a rule, very insoluble, and therefore the analysis is not a true indication of their value. If reduced to very fine state of division the value is increased, and where they are fermented or otherwise specially treated they may be rendered much more soluble.

Vegetable Manures.—*Green-crop Manuring.*—In some parts of England and the Continent a method of manuring is pursued which consists of growing a crop for the express purpose of ploughing it in. Mustard, vetches, rye, lupines, clover, rape, buckwheat, and turnips have been used for the purpose, the requisites being that the crop shall be quick growing, hardy, and somewhat deep-rooted.

This method of "green-manuring" can be carried out on both light and heavy lands with beneficial results; upon the former the roots have the effect of consolidation and of binding it together, while the admixture of so much organic matter mellows the latter.

There are many advantages resulting from their use, of which the following may be taken as typical:—

1. There is a direct addition of plant-food to the soil, as during the growth of the plant it absorbs food from the air, and the upper layers of the soil are enriched by matter brought up from the subsoil, and which, when the plants are ploughed in, becomes almost immediately available for the succeeding crop.

With certain crops this gain in plant-food is much more marked, as it consists in an increase of the *nitrogen* in the soil at the expense of that of the air. The plants which possess this power of abstracting *nitrogen* direct from the air are those belonging to the natural order Leguminoseæ, to which order belong peas, beans, vetches, clovers, sainfoin, lucerne, etc. On the rootlets of the plants of this order are a large number of small nodules, or tubercles. These are the home of micro-organisms capable of abstracting free nitrogen from the air, and forming nitrogenous compounds. The great portion of this nitrogen ultimately finds its way into the plant, and is there made use of.

The benefit is not confined to the leguminous crop alone, but where that crop is ploughed in, or even if only the roots are left, the soil becomes so enriched by the accumulated nitrogen that greatly increased crops result.

Dr. Wagner, of Darmstadt, conducted experiments to test the effect of the above. Two equal plots were taken, and upon one white mustard and on the other vetches were ploughed in, and oats sown. Each received an equal dressing of artificials, but the yield on that where vetches had been ploughed in was twice that on the one where white mustard had been ploughed in.

Similar experiments were conducted by Heiden, rye being taken (1) after lupins, ploughed in, and (2) after bare fallow. The relative yields of the plots were: plot 1, 96 of grain and 205 chaff and straw; plot 2, 56 of grain and 114 chaff and straw.

The importance of this fixation of free nitrogen cannot be over-estimated, as it provides a large quantity of the dearest manurial constituent without cost.

2. The food added to the soil by green-manuring cannot readily be lost by drainage.

This explains the advantage which light land derives from it, that class of land not being usually retentive of plant-food.

3. A large quantity of humus is added to the soil, the benefit of which has already been noticed.

4. During the decomposition of the vegetable matter, mineral matters are rendered available for plant-food, owing to the effects of the products of the decomposition.

It always, however, seems a pity, especially in the eyes of a farmer, to plough into the land what might be providing food for his stock, and he naturally prefers to feed the crop and return the manure to the soil; and probably, all things considered, this is the best plan.

To some extent, however, green-manuring can be and is practised with great advantage. When lea is broken up, that is green-manuring on a smaller scale; and ploughing in turnip-tops, etc., is likewise carrying out the same system.

Seaweed is used largely in districts where a considerable quantity is readily available, and heavy dressings give good results, especially in the case of mangels.

Analysis of Seaweed (Two Samples).

	I.	II.
Water	77·94	85·03
Organic matter	18·12	12·35
Ash	3·94	2·62
	100·00	100·00

The fresh plants contain from ·25 to ·5 per cent. of nitrogen. In the ash there is from 7 to 15 per cent. of potash, 10 to 15 per cent. lime, 4 to 8 per cent. magnesia, 2 to 4 per cent. phosphoric, pentoxide, and a large proportion of common salt.

Refuse Cakes.—Oil-cakes of various kinds are used as manure, either in the form of damaged samples or cheap cakes not fit for food. The composition varies, and the less oil they contain the more valuable will their ingredients become.

An average sample of cake used for manure might contain—Nitrogen, 4 to 9 per cent.; phosphoric acid, 1·5 to 3 per cent.; potash, 1 to 2 per cent.

ARTIFICIAL AND MANUFACTURED MANURES.

These may be divided into *nitrogenous*, *phosphatic*, *potassic*, and *miscellaneous* manures.

Of these we will first consider the nitrogenous manures, as they are perhaps the most important.

All plants require nitrogen for their proper growth, and it is one of the elements in which the soil very readily becomes deficient.

Among nitrogenous manures are nitrate of soda, sulphate of ammonia, nitrate of potash, chloride of ammonia, gas liquor, blood, soot.

Nitrate of Soda.—This manure is obtained from Chili and other rainless districts of South America, where it occurs as an efflorescence on the soil or in thick beds. The whole of the vast deposits have been formed from organic matter by nitrification, and the presence of large quantities of sodium salt has determined the base with which the nitric acid is united.

The crude salt found here contains from 27 to 63 per cent. of $NaNO_3$, but after it has been purified by dissolving and crystallization, the commercial article is obtained, the refraction (or impurity) of which does not exceed 5 per cent.; indeed, it is often much less than that. The percentage of nitrogen is 15·6.

The commonest adulterant of this manure is sodium chloride, in addition to which other sodium salts are used.

The presence of sodium chloride in any quantity may be demonstrated by adding to a solution of the manure a few drops of a solution of silver nitrate, when a white precipitate will be produced. Another proof is obtained by ignition; thus sodium nitrate burns with a clear flame, sodium chloride crackles and leaps about.

Nitrate of Potash.—This substance is rarely, if ever, used as a manure, on account of its high price. It is a very concentrated manure, and supplies both potash and nitrogen to the soil. It is formed in small quantities in compost heaps, in which old lime is mixed. Nitrate of potash (saltpetre or nitre) contains 12 to 13 per cent. of nitrogen.

Sulphate of Ammonia.—This compound is obtained as a by-product in the manufacture of coal gas, and also in the manufacture of steel. During the destructive distillation of coal in the production of coal gas, the greater portion of the nitrogen is evolved as ammonia, and this, on absorption with water, forms the ammoniacal liquors of the gas-works. The liquor is heated with lime, and the ammonia is driven off as a gas, which, on being passed off into sulphuric acid, forms ammonium sulphate ($[NH_4]_2SO_4$).

Sulphate of ammonia should contain 20 per cent. of nitrogen, equal to 24 per cent. of ammonia. If chemically pure it would contain 21 per cent. of nitrogen. Ammonium sulpho-cyanate is sometimes found in this manure, and, as it is very poisonous to vegetation, it should always be tested for. If present, a solution becomes blood-red in colour on addition of ferric chloride. As sulphate of ammonia and nitrate of soda resemble each other greatly, it may be as well to tell how to distinguish between them. The former varies considerably in colour, has a sharp alkaline taste, and, when treated with an alkali, it gives off ammonia gas, which is readily recognized by the smell. When heated on a clean iron plate it volatilizes, leaving little residue, the amount of which is a rough index of the purity of the sample. Nitrate of soda is darker looking, more crystalline, and rougher to the feel than ammonium sulphate. Ammonium sulphate is not so soluble nor so active a manure as sodium nitrate, as it is probable that it must undergo nitrification before it is available for plant food, consequently it is of more use on wet lands and in wet seasons, when it is not so likely to be washed away. It is because of the necessary changes which ammonium sulphate must undergo that it is not so exhausting as nitrate of soda. It does not force the plants so much, and consequently allows them more time to gather up their food. The lower qualities of this manure may contain much moisture, free acid, tarry matter, and sulphate of lime and iron. The nitrogen of ammonium sulphate has not such a high unit value as that of nitrate of soda.

Ammonium Chloride is known also as sal-ammoniac. On account of its expense it is not often used as a manure. It contains about 18½ per cent. of water, and 32½ per cent. of ammonia. According to some authorities, it is not much better than ammonium sulphate in agricultural value.

Gas-liquor.—One ton of coal yields ten gallons of ammoniacal liquor, containing 3½ to 6 ozs. of ammonia per gallon. Gas-liquor is an impure solution of ammonium carbonate and acetate.

Dried Blood contains 10 to 13 per cent. of nitrogen in an active state, and consequently ready almost immediately to be made use of by the crop. The ash contains about 60 per cent. of common salt, 21 per cent. of sodium, calcium, and magnesium phosphates, 6 per cent. potassium chloride, and 8 per cent. of iron compounds.

Fresh Clotted Blood consists of blood with most of the serum expelled by gravitation; the remains are then broken up finely. It contains 5 to 7 per cent. ammonia.

Acid Clotted Blood consists of blood which has been clotted by some acid, such as sulphuric. It contains 5 to 7 per cent. ammonia, and is easily ground to a powder.

Soot owes its manurial value chiefly to small amounts of ammonia (from traces up to 5 per cent.) which it contains. It also has a considerable amount of mineral matter, from 10 to 40 per cent., the chief body being carbonate of lime.

2. Phosphatic Manures are a very important series. Phosphorus is one of the necessary constituents of protoplasm in plants. The following are the chief members of this group :—

Superphosphate of Lime.—This very important manure is made by treating some phosphatic material with sulphuric acid, which to a certain extent dissolves it, forming a more soluble compound. By a superphosphate is now generally meant a manure made from mineral phosphates, and not from bones. The raw phosphate is first ground down to a fine powder between millstones. It is next placed in a strong vessel called a "mixer," and then sulphuric acid is run in to the extent of rather more than half the former quantity of ground phosphate. The acid (sp. gr. 1·5) is run in from a tank above, through a kind of hopper. The acid and phosphate are intimately mixed by means of a revolving spindle, provided with numerous blades set at right angles. The following reaction takes place :—

$$Ca_3P_2O_8 + 2H_2SO = CaH_4P_2O_8 + 2\ CaSO_4.$$

$$\left.\begin{array}{c}\text{Insoluble}\\ \text{tricalcic}\\ \text{phosphate}\end{array}\right\} + \left\{\begin{array}{c}\text{sulphuric}\\ \text{acid}\end{array}\right\} = \left\{\begin{array}{c}\text{soluble}\\ \text{monocalcic}\\ \text{phosphate}\end{array}\right\} + \left\{\begin{array}{c}\text{calcium}\\ \text{sulphate.}\end{array}\right.$$

In a short time the bottom of the mixer is opened by a lever, and the contents, usually from 10 to 20 cwts., fall on the floor of a close chamber, called a "den." The superphosphate is allowed to dry for a day or two, then put through a disintegrator, stored for some time, and is then ready for use.

Sufficient sulphuric acid to convert all the insoluble phosphate into the soluble form is never added, as the resulting superphosphate would be too moist and would be very bad to distribute.

The different forms of mineral tricalcic phosphate are divided into apatite or crystallized, and phosphorite or non-crystallized. Apatite is of two kinds—green from Canada, red from Norway. Canadian apatite contains 70 to 90 per cent. of tricalcic phosphate, combined with calcium fluoride or calcium chloride. Norwegian apatite is the better of the two, so far as solubility goes. It contains about 78 per cent. of tricalcic phosphate, combined with calcium chloride. Of phosphorites there are Charleston river (Carolina), containing 55 to 63 per cent. tricalcic phosphate, and black in colour; Spanish (Estremadura) and Portuguese, containing 75 to 85 per cent. $Ca_3P_2O_8$, of light colour; Belgian; German (Nassau and Lahn), containing $Ca_3P_2O_8$, varying in percentage from 30 to 89 per cent.; French, Boulogne phosphates, containing 44·5 per cent. $Ca_3P_2O_8$; Bordeaux phosphates, with 60 to 77·5 per cent. $Ca_3P_2O_8$; Welsh, found in the Silurian rocks, and of very variable quality; West Indian (Curaçoa, 73 per cent.; Aruba, 67 to 72 per cent.; Navassa, 62 to 70 per cent.; Sombrero, 70 to 75 per cent.; Pedro-keys, 64 per cent.; St. Martin, 68 to 80 per cent.; Redonda). In Cambridge, Suffolk, Bedford, and Buckingham there are found uncrystallized phosphates known as Coprolites. They are brown or greyish nodules, said to be the fossil dung of extinct animals. Cambridge coprolites, found in the Upper Greensand, are of grey colour, and contain 58 per cent. $Ca_3P_2O_8$; Surrey coprolites are brown in colour, and have 45 to 55 per cent. $Ca_3P_2O_8$; Bedford and Bucks coprolites are similar to those of Surrey.

ANALYSIS OF A SUPERPHOSPHATE.

Moisture	17·10
Water of combination	9·63
Monocalcic phosphate	18·01
(Equal to tricalcic phosphate made soluble	28·10)
Insoluble phosphate	2·83
Sulphate of lime	47·01
Insoluble matters	5·42

In an account of an analysis, instead of the amount of monocalcic phosphate in the manure, there is often put the amount of tricalcic phosphate which has been rendered soluble, under the title of "phosphate made soluble," or even of "soluble phosphate."

When the conversion into monocalcic phosphate is incomplete, a reaction may take place between the monocalcic and tricalcic phosphates, in which dicalcic phosphate is formed.

$$Ca_3P_2O_8 + CaH_4P_2O_8 = 2Ca_2H_2P_2O_8.$$

The tendency to form "reduced" or dicalcic phosphate is the greater the more iron or alumina the original phosphate contained. Some chemists believe that insoluble basic phosphates of iron and alumina are formed. At any rate, the reduced or retrograde phosphate is not so soluble as the monocalcic form, and hence is of lower value. It is, however, more soluble than tricalcic phosphate, although it is often valued at the same price.

Dissolved Bones.—This manure is manufactured in a similar manner to superphosphate, but bones are used instead of mineral phosphates.

ANALYSIS OF A SAMPLE OF DISSOLVED BONES.

Moisture	17·37
Organic matter and water of combination[1]	12·59
Monocalcic phosphate[2]	19·20
Insoluble tricalcic phosphate	10·93
Calcium sulphate, magnesia, and alkaline salts	37·62
Insoluble silicious matter	2·29
	100·00

Owing to the organic matter in bones (amounting to nearly 40 per cent.), it is often difficult to dissolve them sufficiently. When boiled, much of this organic matter separates out as gelatine. The bones dissolve more easily, but there is a loss of nitrogen. The tricalcic phosphate of bones, owing to its greater solubility in the soil, has a money value, whereas that of mineral superphosphates has practically none.

Bone-ash Superphosphate.—The ashes, imported in large quantities from South America, are obtained chiefly by burning the bones of cattle. The superphosphates contain little or no nitrogen, and 25 or 26 per cent. monocalcic phosphate.

Bone Black is a valuable manure obtained from sugar refineries. It consists of animal charcoal, which has been used for decolourizing sugar. It contains from 72 to 87 per cent. of calcium phosphate, mostly in the tricalcic form. It may be used as it comes from the refineries, or after being dissolved in sulphuric acid.

Dissolved Phosphatic Guano.—Genuine guano, dissolved in sulphuric acid, may contain 40 to 45 per cent. of soluble phosphate (Warington). Many of the "dissolved guanos" consist of guano, treated with oil of vitriol, to which has been

[1] Containing nitrogen, 0·86 (equal to ammonia, 1·04).
[2] Equal to phosphate made soluble, 30·07.

added some dried blood, sulphate of ammonia, or other body containing ammonia; they are then said to be fortified. The compound thus formed may contain 20 to 23 per cent. soluble phosphate, 3 or 4 per cent. insoluble phosphate, and 8 per cent. ammonia. Dissolved guano is a quick-acting manure, of great use on strong lands.

Raw Bones.—These are often used without being chemically treated. They contain 49 per cent. of tricalcic phosphate, and 4 or 5 per cent. of ammonia. Bones are ground down to various degrees of fineness, such as half- and quarter-inch bones, etc.

Half-inch Bones have been much used for pastures. On such soils, there is often a want of phosphates, owing to the demand by young cattle for bone formation, and by cows for their milk. This want the half-inch bones gradually supply, but their action is very slow. They are apt to be carried away by such birds as crows and rooks.

Quarter-inch Bones are more rapid in their action than the last, but still are very slow when compared with such manures as nitrate of soda or superphosphate.

Bone Dust consists of bones ground to a rough powder. It becomes more readily available than the two preceding manures.

Bone Meal is in a finely divided state, and is often adulterated with sulphate of lime, etc. When of good quality it contains 49 per cent. tricalcic phosphate, 3 or 4 per cent. ammonia, 9 or 10 per cent. carbonate of lime, and 2 to 5 per cent. alkaline salts.

Bone Flour is the most finely divided, and consequently acts most quickly. It has nearly the same composition as bone meal. Apply at the rate of 9 to 15 cwts. per acre.

Fermented Bones are prepared by mixing them with a quarter of their weight of clay, and then saturating with liquid manure. Cover over the heap with clay to protect it from the rain, and allow it to stand for a week or two. The organic part of the bones begins to decompose, and the whole mass gradually crumbles. The resulting manure is very soluble, and gives good results on turnips and grass land.

It will be seen that the value of bones depends greatly upon the degree of fineness of their particles; the finer they are, the more readily will they dissolve. The fatty matter in bones interferes greatly with their solubility, and hence it is thought best to have as much of it as possible extracted before using. This is done by boiling or steaming, by which means not only the fat, but a considerable portion of the gelatine, etc., is also extracted. The operation causes a loss of 1 or 2 per cent. of nitrogen to the bones.

Basic Slag is a valuable phosphatic manure, known also as Basic Cinder and Thomas's Phosphate Powder. It contains 14 to 20 per cent. of phosphoric acid (equal to 32 or 42 per cent. of tricalcic phosphate); about 50 per cent. lime; oxides of iron, etc., 22 per cent.; silica and magnesia, 10 per cent. The phosphoric acid exists chiefly as a tetrabasic phosphate of lime ($[CaO]_4P_2O_5$). This is not a very stable compound, and hence it readily dissolves in the soil.

Precipitated Phosphate is similar to reduced phosphate, but here lime has been added artificially to monocalcic phosphate, and the manure consists of mono-, di-, and tri-calcic phosphates. The tricalcic phosphate in this state is in a fairly soluble condition, and the manure is very useful on light sandy soils.

3. Potash Manures.—Potash is not so much used as a manure as nitrates and superphosphates. It is generally contained in sufficient amounts in the soil, but still is of great use when applied to such crops as potatoes and nearly all leguminous crops.

Kainit is obtained chiefly from the mines at Stassfurt and Leopoldshall in Germany. It contains about 24·5 per cent. sulphate of potash, 13 per cent. magnesium sulphate, 14 per cent. magnesium chloride, and 30 per cent. common salt.

Sulphate of Potash is obtained from Germany. It occurs crystallized in four-sided prisms and double six-sided pyramids. Kainit is a common source. It contains 54 per cent. of potash when pure.

Polyhalite is a double sulphate of potash and magnesia, containing about 49 per cent. of the former, and 39 per cent. of the latter. It occurs in a deposit at Stassfurt.

Muriate or Chloride of Potash is obtained as a by-product in the manufacture of chlorate of potash, and also from carnallite. It crystallizes in cubes, and decrepitates when heated. The commercial form is usually about 80 per cent. pure.

Carnallite.—This is a double chloride of potash and magnesia ($KCl,MgCl_2 + 6H_2O$), containing 39 per cent. moisture, 27 per cent. potassic chloride, and 34 per cent. magnesic chloride. In its ordinary form it may have 1 or 2 per cent. of sulphates, and a little lime and soda. It is generally purified by crystallization until it contains 80 per cent. potassic chloride.

Grugite is another potash salt, containing about 11 per cent. of potash in the form of a sulphate.

Carbonate of Potash is occasionally used as a manure. It is found largely in wood-ashes.

Wood-ashes.—These contain from 5 to 15 per cent. of potash; the ashes from the leaves and young twigs containing

more than those from the other stems and branches. Beech-ashes also contain a considerable quantity of phosphates. Wood-ashes may be used as they are, or the carbonate and oxide of potassium may be changed into the more valuable nitrate. For this purpose, wood-ashes are mixed in a compost with organic matter and lime. During the decomposition, nitric acid is formed from the organic matter. This combines with the lime, forming nitrates of lime, and this in turn is decomposed by the carbonate of potassium, forming the nitrate. The whole mixture also forms an excellent manure.

Salts recovered from Sheep-washing.—Wool often contains much of a substance called "suint;" indeed, with merino sheep, it may amount to one-third the weight of the fleece. Suint contains 50 per cent. organic matter, 44·5 per cent. carbonate of potash, 2·5 per cent. sulphate of potash, 3 per cent. chloride of potash. In France the potash salts are extracted from the wool, and used as manure.

4. Miscellaneous Manures.—(*a*) Lime compounds; (*b*) salts of soda, magnesia, and iron; (*c*) silica.

(*a*) **Lime Compounds.**—The forms of lime usually applied to land are quicklime, slaked lime, gas-lime, sulphate of lime, chalk, marl, shell sand, corals.

Lime is, next to nitrogen, phosphoric acid, and potash, the most important plant-food. It is contained in considerable proportions in the ashes of all plants. The ash of wheat grain contains 10½ per cent. lime, of beans 7 per cent., of meadow hay 18 per cent., of mangels 13½ per cent., of cabbages 15½ per cent., of turnip roots 13 per cent., of turnip leaves 35½ per cent., of potato tubers 3 per cent., of potato haulms 17 per cent., of stem of vine 44 per cent., cherry stem 22 per cent., olive stem 14½ per cent.

By lime, as the term is ordinarily used, is meant burnt or caustic lime. It is obtained, as has already been stated, by burning limestone.

Mountain and magnesian limestones are the principal forms used. An ordinary limestone contains about 94 per cent. carbonate of lime, 2 per cent. carbonate of magnesia, 1·5 per cent. alumina and ferric oxide, 2 per cent. calcic sulphate and phosphate, 0·5 per cent. silica. After burning, the quicklime contains 90 per cent. of calcic oxide. One ton of limestone yields 11¼ cwt. quicklime, weighing 75 to 112 lbs. per bushel.

The effect of lime has been fully dealt with under "Liming," and it will be unnecessary to touch on anything but the special lime manures, "gas-lime," etc.

Gas-lime.—In the manufacture of coal gas, quicklime is used

to absorb various gaseous impurities, being afterwards sold as gas-lime. This consists chiefly of slaked lime, and carbonate of lime, with calcium sulphate and sulphite. The following analysis gives the composition of an average sample, but it must be remembered that they vary greatly: water, 30·1; slaked lime, 31·0; calcium carbonate, 17·4; calcium sulphate and sulphite, 20·0; ammonia, ·01; iron oxide and alumina, 1·5 per cent.; calcium thiocyanate, traces. In its fresh state, the sulphites, and the traces of sulphide and thiocyanate cause it to have an injurious effect. It should be exposed to the air for some time in order that the poisonous bodies may be oxidized, and hence it should be applied in autumn.

Sulphate of Lime ($CaSO_4 + 2H_2O$).—The common name is Gypsum. It is most suited for such crops as turnips, clover, grasses, potatoes, and mustard, which contain a considerable percentage of sulphur in their ashes. Leguminous crops are generally benefited by its application.

Gypsum costs about 10*d.* per cwt., and is applied at the rate of 2 to 10 cwts. per acre. Superphosphates contain considerable amounts of calcium sulphate, 5 cwts. of superphosphate containing 2 cwts. of gypsum. Hence, when that manure is given to the land, no sulphate of lime is needed. It has the power of absorbing and fixing ammonia in the soil and in manure-heaps, forming probably ammonium sulphate and calcium carbonate. Gypsum is said to partially decompose the rock materials, liberating potash and other valuable ingredients. This is probably owing to the sulphuric acid which it contains. On the other hand, it is said that gypsum promotes the formation of woody fibre, adding to the luxuriance of the vegetation; that it prolongs the period of growth of the plant, delaying the time of its maturity.

Marls consist of a mixture of clay and lime. They also contain small amounts of phosphoric acid and potash. The percentage of carbonate of lime in them varies considerably, some of the chalk-marls containing 70 per cent. They sometimes contain 4 per cent. of phosphates. When the cost for carriage is not too great, they form a good manure. Marls may be used in making composts, or ploughing into arable land. They improve peaty soils greatly. As they are intermediate in physical properties between clays and sands, marls are useful on both.

Shell Sands consist of broken pieces of shells mixed with a varying amount of sea-sand. They contain from about 20 per cent. of carbonate of lime in poor varieties to 50 per cent. in good ones. Shell sands are useful on peaty soils and hillside pastures.

Corals.—These are only obtained on some parts of the coast,

and have a very limited use. They may be used as a powder, or in composts. When fresh, they contain as much as 15 per cent. of organic matter, in addition to carbonate of lime, and a little phosphate.

Chalk is similar to the forms of carbonate of lime already treated. It contains 80 to 97 per cent. of calcium carbonate. It may be dug out of pits and spread over the land, while still wet, at the rate of 30 to 80 cubic yards per acre. It is a useful manure for sandy soils.

(*b*) **Salts of Soda.**—Sodium chloride, sodium sulphate, sodium carbonate.

Sodium Chloride, or Common Salt ($NaCl$).—Usually is of little value for its direct action. Sodium, although closely allied to potassium, cannot take its place as a plant-food, and hence is of little use as a manure. Chlorine, though said to be essential to buckwheat, does not benefit ordinary plants greatly. Common salt, however, is a direct plant-food in small proportions, and is very useful for mangels and cabbages, originally sea-side plants. When applied with nitrate of soda, salt reduces the tendency to over luxuriance of leafage. This checking action is probably due to the chlorine of the salt. Sodium chloride is said to increase the weight per bushel of grain. On pastures it is of use in destroying coarse herbage. Common salt, when applied with farmyard manure and guano, renders both of these manures more efficacious by acting on the insoluble nitrogenous matter, and forming ammonium chloride. Salt is very useful in neutralizing sour organic bodies in the soil. Ammonia is set free; this unites with chlorine, while the sodium forms a carbonate. Sodium chloride destroys the seeds of many weeds, and it is also well known that on salt marshes certain diseases do not appear. The salt either destroys the bacteria causing the disease, or the medium through which the disease passes. Salt improves the power of certain soils for absorbing moisture from the atmosphere.

Sodium Sulphate is obtained as a by-product in the manufacture of nitric acid from nitrate of soda.

$$2NaNO_3 + H_2SO_4 = Na_2SO_4 + 2HNO_3.$$

$$\left.\begin{matrix}\text{Nitrate of}\\ \text{soda}\end{matrix}\right\} + \left\{\begin{matrix}\text{sulphuric}\\ \text{acid}\end{matrix}\right\} = \left\{\begin{matrix}\text{sodium}\\ \text{sulphate}\end{matrix}\right\} + \left\{\begin{matrix}\text{nitric}\\ \text{acid.}\end{matrix}\right.$$

Glauber's salts is the common name for the crystallized sodium sulphate. The ordinary form is 94 to 98 per cent. pure.

Salts of Iron.—The only one used as a manure is the sulphate.

Sulphate of Iron ($FeSO_4 + 7H_2O$). Iron is one of the ingredients necessary to the plant, though only required in very small quantities. It is contained in the chlorophyll granules, and

gives the green colour to leaves. Iron sulphate is said to increase the albuminoids and carbohydrates in the plant, thus causing it to have a higher feeding value.

Salts of Magnesia.—It is very seldom that these are used as manure, except in experiments. They are taken up in small amounts by the plant, and the soil generally contains a sufficient supply. M. Ville states that magnesia is essential to plant life.

Sulphate of Magnesia is commonly known as "Epsom salts." It is never used by itself, in practice, although in mixtures it is said to benefit corn and clover crops. It has also been recommended in a top-dressing for potatoes.

Phosphate of Magnesia has been stated to act beneficially to potatoes. It will, however, scarcely pay its cost of application.

(*c*) **Silica** is contained in fairly large quantities in the ash of most plants. The ash of wheat straw contains 66 per cent. silica; the ash of barley straw, 51 per cent. Although such large amounts are thus taken up, it is not to be supposed that it is essential to plant life. The silica is absorbed by the plant as silicates of potash, etc. The potash is made use of, and then the silica is excreted in the straw. The manures called "Soluble Silica" are generally of no good whatever. M. Ville says that the absence of soluble silicates from the soil, however, prevents the proper growth of plants. Professor Wrightson asserts that silica is worthless, and sometimes even injurious to the plant. It coats itself round the cells, clogging them up, and preventing their proper action.

Directions for the Use of Manures.—Whenever a farmer buys any artificial manure he should always get a written guaranteed analysis. From this analysis he will be able to calculate the value of the manure. This is done by multiplying the percentage of each constituent by its unit value. Thus, say he bought some dissolved bones, he could, by the following method, find its value.

	Per Cent.		Unit Value. *s.*	*d.*		£	*s.*	*d.*
Ammonia (contained in the organic matter) ..	1·0	@	10	3	=	0	10	3
Phosphate made soluble	30·0	@	2	8	=	4	0	0
Insoluble phosphates	10·9	@	2	6	=	1	5	5
Alkaline salts, etc.	37·6	@	0	4	=	0	12	4
						£6	8	0

The unit is really the price of $\frac{1}{100}$ ton of the substance. It varies according to the solubility of the ingredient, and therefore according to the material the constituent is derived from. Thus, the phosphates in basic slag are worth 9*d.* per unit; in guanos they are valued at 2*s.* 2*d.*

Mixing Manures.—In performing this operation, great care should be exercised that no chemical action takes place which may cause the value of the manure to deteriorate. Thus, when alkaline ashes or quicklime are mixed with a body containing ammonia, a loss of the latter substance through evolution occurs; thus—

$$(NH_4)_2SO_4 + CaO = 2NH_3 + CaSO_4 + H_2O.$$

$$\left.\begin{matrix}\text{Ammonium}\\\text{sulphate}\end{matrix}\right\} + \left\{\begin{matrix}\text{quick-}\\\text{lime}\end{matrix}\right\} = \text{ammonia} + \left\{\begin{matrix}\text{sulphate}\\\text{of lime}\end{matrix}\right\} + \text{water.}$$

This is the reason why basic slag and sulphate of ammonia should never be mixed. When nitrate of soda is added to superphosphate, the sulphuric acid of the latter unites with the soda to form sulphate of soda on standing. The nitric acid is set free as nitrous fumes (N_2O_3), and a great loss of nitrogen occurs. The two manures should either be mixed *directly before* sowing, or be applied separately. When superphosphate is mixed with bones or basic cinder, some of the soluble monocalcic phosphate of the former takes up more calcium and becomes reverted to a greater or less extent.

Classification of Manures according to their Composition and Action.

1. *Nitrogenous Manures.*

(*a*). Substances containing nitric acid (very quick acting).
- Nitrate of potash (saltpetre).
- Nitrate of soda (Chili saltpetre).

(*b*). Substances containing ammonia (quick acting)
- Sulphate and chloride of ammonia.
- Gas-liquor.
- Peruvian guano.
- Putrid animal substances: blood, flesh, wool.
- Putrid urine and liquid manure.
- Short dung.
- Poudrette and nightsoil.
- Soot.

(*c*). Nitrogenous matters which easily putrefy (tolerably quick acting).
- Dissolved and finely ground bones.
- Fresh urine and liquid manure.
- Malt dust.
- Refuse cakes of all kinds.
- Long dung.

(*d*). Nitrogenous manures which decompose with difficulty (slow acting).
- Half-inch and quarter-inch bones.
- Horn-shavings; glue; refuse hair.
- Woollen rags; shoddy; leather waste, etc.

2. *Phosphatic Manures.*

Dissolved bones and dissolved guano.
Fermented bones.
Superphosphate.
Bone meal, dust and flour; bone black.
Guano.
Farmyard manure; human egesta; organic refuse.
Basic slag.
Ground phosphatic minerals.
Raw bones.

3. *Potassic Manures.*

Potassic nitrate, sulphate, chloride.
Kainit; polyhalite; carnallite; grugite.
Wood ashes; green manures.
Farmyard manure; urine; composts.

4. *Calcareous Manures.*

Burnt lime; chalk; marls; shell sand; corals.
Gypsum; gas-lime.

5. *Sodic Manures.*

Sodium chloride and sulphate.

6. *Ferric Manures.*

Iron sulphate.

7. *Magnesic Manures.*

Sulphate and phosphate of magnesia.

C.—*Chemistry of the Plant.*

Chemical Composition.

When a plant is subjected to heat, (1) the water is driven off; (2) the organic matter becomes oxidized or burned, and is driven off in a gaseous state; (3) nothing but a small amount of inorganic matter remains.

The amount of water varies very much according to the kind of plant and its age. Turnips contain 91 per cent. water; meadow grass, 72 per cent.; and even timber, felled at the driest part of the year, has 40 per cent.

Water exists in all parts of the plant, and is absolutely essential to life. It is present in two different conditions: (1) as free water of vegetation, which is expelled by ordinary drying, as in making hay; and (2) water of combination, which is only got rid of by exposing air-dry plants for several hours, at a temperature of 212° F., in a warm water-bath.

The *organic matter*, or combustible part of the plant, consists chiefly of carbon, combined with hydrogen and oxygen, and in some cases nitrogen and sulphur, with traces of phosphorus.

Dry organic matter	Carbon, about 50 per cent.
	Oxygen, ,, 40 ,, ,,
	Hydrogen ,, 5 ,, ,,
	Nitrogen, from ½ to 4 per cent.
	Sulphur, ,, 1 to 4 ,, ,,
	Phosphorus, traces.

The Organic Constituents of Plants.

The organic substances found in plants are almost innumerable. Nearly every plant possesses some organic body peculiar to itself, in addition to the usual constituents of all vegetation.

The organic bodies may be divided into the following groups :—

1. Carbohydrates	Amyloids $(C_6H_{10}O_5)n$	Starch, cellulose, lignin, inulin, dextrin, gum.
	Sugars	Cane sugar (saccharose) $C_{12}H_{22}O_{11}$.
		Fruit ,, (lævulose) $C_6H_{12}O_6$.
		Grape ,, (glucose) $C_6H_{12}O_6$.
		[Milk ,, (lactose) $C_{12}H_{22}O_{11}, H_2O$.]
2.	Fats	Palmatin, $C_3H_5(OC_{16}H_{31}O)_3$
		Stearin, $C_3H_5(OC_{18}H_{35}O)_3$.
		Olein, $C_3H_5(OC_{18}H_{33}O)_3$.
	Oils, such as olive, colza, linseed, mustard.	

3. Pectose Group—Pectose, pectin, pectic acid.

4. The Vegetable Acids	Oxalic, $C_2H_2O_4 + 2H_2O$.
	Tartaric, $C_4H_6O_6$.
	Malic, $C_4H_6O_5$.
	Citric, $C_6H_8O_7$.

	Vegetable.	Animal.
5. The Albuminoids (or Proteids)	(*a*) Vegetable albumin	= Albumin of egg.
	(*b*) Vegetable casein of flour ; legumin of bean	= Casein of milk.
	(*c*) Vegetable fibrin of flour	= Fibrin of meat.

6. Amides.—Diffusible nitrogenous bodies, such as asparagin, $C_2H_3(NH_2)(CO,NH_2)(CO_2H)$.

7. Extractives, such as chlorophyll, tannin, and the alkaloids.

1. Carbohydrates.

(A) **Cellulose Group**, consisting of bodies of the formula $(C_6H_{10}O_5)n$.

Starch is the first visible substance manufactured by the leaves

during the process of assimilation. It is found more or less in all plants; in the seeds of wheat, Indian corn, and other grain, the tuber of the potato, wood of forest trees, pith of the sago-palm, and root of the manihot.

It is one of the most valuable constituents of vegetable food, many plants being grown for the sake of the starch alone.

Under the microscope starch is seen to be made up of numbers of small white glistening granules consisting of concentrically arranged layers.

Starch is the usual insoluble form in which plants store up their carbonaceous matter to be used for purposes of future growth. When required, it is readily converted into soluble sugar by the aid of a ferment.

Tests for Starch.—A drop of solution of iodine turns starch a beautiful dark blue. Bromine colours it bright yellow.

Cellulose ($C_{12}H_{20}O_{10}$) has the same chemical composition as starch. Cell walls chiefly consist of this substance, at least in their earlier stages. It is a white amorphous powder.

We have said before that every plant is made up of a number of microscopic cells, the partitions between them being called *cell walls.* These cell walls are formed through the agency of living protoplasm within the cell. At first thin, they become thickened by successive layers of cellulose.

It is very insoluble in either acids or alkalis, but boiling for some hours with sulphuric acid converts it into sugar. The test for cellulose is to add strong sulphuric acid, and, after a time, a drop of iodine, when a blue colouration will result. After the protoplasm has disappeared from the cell, the cell-wall in many cases becomes converted into *lignin*, or woody fibre.

Lignin turns yellow with iodine, and brown when treated with iodine and sulphuric acid.

Inulin replaces starch in the roots of many Compositæ, such as the artichoke, dahlia, chicory, and dandelion.

Dextrin, or British Gum, found in small amounts in the sap of many plants, is a transition stage between starch and glucose (grape sugar), which may be formed from starch by heating it to a high temperature.

Dextrin is soluble in cold water. When starch is digested for some time with a weak solution of sulphuric acid, it is converted first into dextrin and then into glucose. The action of the ferment ptyalin in the saliva of animals produces the same chemical changes.

The various gums, such as gum arabic and mucilage, are degradation products formed by disintegration of the cell-wall.

(B) **Sugars.**—**Cane Sugar**, or Saccharose ($C_{12}H_{22}O_{11}$), is found

in the juice of the sugar-cane, beet-root, turnip, carrot, parsnip; and in spring time can be obtained from the ascending sap of many trees, such as the sugar-maple. It is readily soluble in water, and very sweet.

When acted on by yeast or dilute acids, it is converted into equal parts of lævulose and glucose. It is not directly fermentable, but under the action of yeast in a warm atmosphere it splits up into lævulose and dextrose, which then ferment, yielding alcohol and CO_2.

Grape Sugar, or Glucose ($C_6H_{12}O_6$), is found in the juice of the grape, and in many fruit and vegetable juices, combined with lævulose. It is also formed during the germination of most seeds. It is soluble in water, does not crystallize so readily as cane sugar, nor is it so sweet. It can be formed from starch by the action of warm dilute acids. The starch is first converted into dextrin, and then into glucose.

Fruit Sugar, or Lævulose ($C_6H_{12}O_6$), is found, in combination with other sugars, in honey and many sweet fruits. It is incapable of crystallizing, and exists as a very sweet syrup.

Milk Sugar, or Lactose ($C_{12}H_{22}O_{11}$, H_2O), should be mentioned while dealing with sugars. It is prepared from whey by evaporation and crystallization. It is sparingly soluble in cold water, and does not readily ferment with yeast. Sour milk is caused by milk sugar splitting up into lactic acid under the influence of the lactic acid ferment. The great lesson to be learned from a study of the chemistry of the starches and sugars is the simplicity and ease with which they are converted from one form into another, the change consisting generally in the addition or subtraction of one molecule of water. In nature, these changes are brought about chiefly through the agency of ferments.

2. Fats and Oils.

These substances contain a larger proportion of carbon and hydrogen and less oxygen than the carbohydrates, and are therefore capable of giving out a greater amount of energy when they are oxidized, consequently they are more valuable as food substances. They are found in nearly all parts of plants, but chiefly in seeds, as, for example, flax, hemp, cotton, cabbage, cocoa-nut, palm-nut, etc., which contain large quantities of oil, whilst most seeds contain some amount, even oats and wheat. The bloom seen on the leaves and stems of many plants, the Swedish turnip for example, and on fruits, as the grape, consists of extremely small particles of wax.

All the various fats and oils consist of the mixture in different

proportions of a few elementary fats, the chief of which are palmatin, stearin, and olein.

Origin of Fats and Oils.—All the vegetable oils found in seeds or elsewhere are the production of living protoplasm, starch or sugar being consumed in the manufacture. Most of the oily seeds contain starch at first, which is replaced when ripe by oil.

3. The Pectose Group.

Pectose is a substance found in unripe fruits and roots. It is probably an altered form of cellulose; and when the fruits and roots ripen the pectose becomes softened and converted into pectin.

The same change takes place in the baking of apples and pears, and in the boiling of turnips and carrots.

4. The Vegetable Acids.

These are very numerous, occurring either free or in combination with lime, potash, magnesia, etc., and forming acid salts.

The most important are—

Oxalic Acid ($C_2H_2O_4,2H_2O$), found in the rhubarb, sorrel, and the acid sap of most plants.

Malic Acid ($C_4H_6O_5$), the principal vegetable acid in the sap of most fruits, especially when unripe.

Tartaric Acid ($C_4H_6O_6$), found in the juice of the grape, pineapple, etc.

Citric Acid ($C_6H_8O_7$), present as a free acid in lemons and oranges. It is also found accompanying malic acid in most unripe fruits.

5. The Albuminoids, or Proteids.

These are bodies of a very complex nature found in animals and vegetables. In addition to carbon, hydrogen, and oxygen, they contain nitrogen and traces of sulphur and phosphorus. The exact chemical formulæ of albuminoids is not known, and even the percentage composition is found to vary. It may be remembered, though, that they consist of over 50 per cent. of carbon, about 21 per cent. of oxygen (the same percentage of oxygen as there is in air), about 16 per cent. of nitrogen, 7 per cent. of hydrogen, and 1 per cent. of sulphur.

Vegetable Albuminoids are found in every part of the plant in some stages of its growth. Especially are they found in seeds and young growing plants.

Vegetable Albumin is found in solution in the sap of fresh plants, and coagulates when heated, like white of egg, to which it corresponds.

Vegetable Fibrin.—When wheat-flour is made into dough and kneaded for some time in a stream of water, the starch of the flour is gradually washed away, and a sticky mass remains, known as crude gluten. This gluten consists of at least four albuminoids combined with some starch and fat.

When treated with dilute alcohol a solution is obtained which, upon evaporation, yields an albuminoid known as gluten-fibrin.

Another albuminoid, called gluten-casein, and insoluble in alcohol or water, remains behind. It resembles the casein of milk very much in properties.

Legumin, the principal albuminoid of the seeds of leguminous plants (beans, peas, clover, etc), is, like casein, insoluble in water or alcohol, but soluble in water containing earthy phosphates.

Tests for albuminoids—

1. Stained yellow by iodine.
2. Coloured bright yellow when boiled with nitric acid; on the addition of ammonia the yellow changes to orange.
3. When boiled with Millon's reagent (a solution of nitrate of mercury in nitric acid), a reddish-coloured precipitate is produced. (This is a very delicate reaction.)

6. Amides.

These nitrogenous bodies closely resemble ammonia. They are crystalline, and soluble in water. They readily diffuse through moist membranes, differing in these respects from albuminoids, most of which are insoluble in water, non-crystalline, and indiffusible. The most important of them is asparagin. They are found in seeds during germination and in the growing parts of plants. They no doubt take a very important part in the transfer of albuminoids from one part of a plant to another.

An *amide* may be derived from an acid by the substitution of amidogen (NH_2) for hydroxyl (HO), or from ammonia by the substitution of an acid for hydrogen.

7. Extractives.

Chlorophyll.—This is a name given to the green colouring matter found in the cells of the leaves of most plants. Upon examining a section of a green leaf, it is found that the green colour is due to the small granules embedded in the protoplasm of the cells, called *chlorophyll corpuscles.* Under the influence of

sunlight and the presence of carbon dioxide, starch grains are found in the interior of the chlorophyl corpuscles. During darkness these starch grains disappear, being transformed into soluble sugar, and carried away in the elaborated sap for the nourishment of various organs.

The presence of iron is necessary for the development of the green colouring matter of chlorophyll.

Tannin is the name given to a bitter astringent substance, closely related to the carbohydrates, found in the leaves, bark, and unripe fruits of many plants—oak bark and tea leaves, for example. The presence of tannin in tea is shown by the black colouration when a drop of strong tea falls upon a steel knife.

The alkaloids are organic bases occurring in the bodies of plants and animals, either ready formed, or during destructive distillation of complex organic bodies. They are all derivatives of ammonia.

The fact that many of them are deadly poison is interesting to agriculturalists; cattle and horses often being poisoned by eating herbs or trees containing them. It is important to remember that those free from oxygen are volatile, so that many plants, like hemlock, fool's-parsley, and the common buttercup, poisonous in their natural state, are harmless when dried and made into hay.

1. *Volatile*, without oxygen.

Coniine, found in the hemlock, water-parsnip, cowbane, and many umbelliferæ.

Nicotine, in tobacco.

2. *Oxidized bases*, decomposed on distillation.

Caffein, found in coffee and tea.

Theobromine, found in the cacao-bean.

Morphia and **laudanum** are obtained from opium, the juice of the poppy.

Quinine, from the Peruvian bark.

Strychnine, from the nux vomica, or vomit nut.

Atropine, from the deadly nightshade.

Aconite, the most deadly of all vegetable poisons, from the monkshood.

The leaves and berries of the yew are extremely poisonous. Cattle and horses are constantly poisoned from eating the clippings of the yew tree, which should always be burned.

The Ash of Plants.

When any part of a plant is burned in air the organic matter is decomposed, and fresh and simple combinations with oxygen

are formed. Some of these are volatile, and pass away as gases or vapour. These volatile compounds are chiefly water, carbonic acid gas, oxides of nitrogen, with traces of sulphur dioxide and phosphorus pentoxide.

In the ash that remains behind may be found the following elements.

Non-metals.	*Metals.*
Oxygen.	Potassium.
Carbon.	Sodium.
Sulphur.	Calcium.
Phosphorus.	Magnesium.
Silicon.	Iron.
Chlorine.	Manganese.

Nitrogen may sometimes be found in the ash in the form of a cyanide.

The six elements, potassium, magnesium, calcium, iron, sulphur, and phosphorus, are always present in the ash, and they are indispensable to the life of the plant. Iron is present in only a minute quantity.

The largest proportion of ash is found in the leaves of plants, and the least in the timber of large trees.

The metals of the ash occur in the plant in the form of salts, as—

Inorganic acids	Phosphates Nitrates Silicates Sulphates Chlorides	of	Potassium. Sodium. Calcium. Magnesium. Iron. Manganese.
Organic acids	Oxalates Malates Tartrates Citrates		

During combustion the nitrates and vegetable salts of organic acids are decomposed, and the bases are found in the ash in the form of carbonates or oxides.

Chemical Changes taking Place in the Plant.

1. Chemical substances absorbed, and the part they play in the economy of the plant.

Oxygen.— Oxygen is taken up by plants either free in the gaseous condition, or in the form of water or salts. The free oxygen plays the part of oxidizing the tissues and reducing them to more simple forms, especially CO_2, whilst the combined oxygen enters into the composition of those bodies which help to build up the tissues.

Hydrogen.—Hydrogen is absorbed by all plants, combined

with oxygen in the form of water, combined with nitrogen in the form of ammonia or its compounds.

Carbon.—Green plants obtain their carbon by the decomposition of CO_2 in the chlorophyll granules during sunlight. The carbon absorbed is used for the formation of substances which either take part in the building up of the plant, or undergo decomposition, setting free energy. (This will be more fully considered under the head of "Assimilation.")

Nitrogen.—Nitrogen, as a rule, is absorbed only in combination, but exception must be made in favour of the plants belonging to the natural order of Leguminosæ, which absorb free nitrogen from the atmosphere by the aid of special bacteria found in the tubercles of the roots.

The chief nitrogenous compounds absorbed by plants consist of ammonia and its compounds, and nitrates.

Boussingault concluded that the higher plants flourish best when supplied with nitrates, and the lower plants with ammonia, but it has been shown by experiment that this is not always the case. Many plants prefer ammonia salts to nitrate. The beet root and the tobacco plant are well-known examples. Nitric acid can be absorbed in the form of nitrates of soda, potash, lime, magnesia, and ammonia; and ammonia is taken up in the form of chloride, sulphate, nitrate, and phosphate. The carbonate is said to be injurious. Nitrogen is especially required for the protoplasm of young cells; therefore no active growth can take place without nitrogen.

Sulphur.—Sulphur is absorbed in the form of sulphates, chiefly those of ammonium, potassium, calcium, and magnesium. All that is known of the use of sulphur is that it forms an essential constituent of proteids.

Phosphorus.—Phosphorus is taken up by plants in the form of phosphates. It enters into the composition of protoplasm, and has some relation to the activity of the chemical changes which are always taking place in living protoplasm.

The greatest increase of phosphorus in the plant takes place during the period of its most active development.

According to Lawes and Gilbert, phosphates exercise an influence upon the assimilation of nitrogen. The addition of a soluble phosphatic manure will enable a plant to take up a larger quantity of nitrogen.

Nitrogenous manures are often wasted by applying large dressings without adding a small amount of phosphate.

Potassium.—Potassium is taken up in the form of sulphate, chloride, phosphate, and silicate. The chief function of potash seems to be *starch formation.*

If potash does not enter into the food of plants, no starch is formed. A further proof in support of potash being chiefly concerned in the production and storing up of starch is, that the organs in which these processes are taking place, the leaves, tubers, and seeds, are very rich in potash.

Sodium.—Sodium is always present in the ash of plants, but only in small quantities, except in seaweeds. It cannot replace potassium in the nutrition of the plant, and has no important function.

Calcium.—Calcium is supplied to plants in the form of sulphate, phosphate, nitrate, and carbonate. The chloride has an injurious effect upon all vegetation. The exact use of calcium to plants is not quite known, but one of the most important functions is certainly that of neutralizing the organic acids which are excreted within the tissues. Crystals of calcium oxalate are especially found in the cells of many plants, where they have been apparently excreted from the sap.

Magnesium.—Magnesium is taken up in the same way as calcium, all its salts being beneficial but the chloride. Very little seems to be known as to its function.

Iron.—Iron can be absorbed in the form of all its soluble compounds.

It is essential to all green plants. Without it, plants would be colourless and develop no chlorophyll. Although iron does not enter into the chemical composition of chlorophyll, yet it affects the processes in the cell which lead to its formation.

Chlorine.—Chlorine is a very constant constituent of plants, although it does not seem to be essential. It has been considered as necessary for buckwheat, because, when no chlorine was supplied, the chlorophyll granules became overburdened with starch.

It would thus seem to have some bearing on the translocution of starch.

Vines, however, considers this effect to be only indirect, the chloride being the compound of potassium, which has most effect on the plant.

Silicon.—Silicon is absorbed in the form of silicates, and sometimes soluble silica. Silica is always present in the ash of plants, and is chiefly located in the cell wall. It is very abundant in grasses and cereals. It must be distinctly understood, however, that silica is not essential to the nutriment of the plant, and therefore is not a plant-food. Professor Wrightson especially insists on this point. It was first suggested by Sir Humphry Davy, that the cause of "laying" of wheat was an insufficient supply of silica. It has since been demonstrated that the

stiffness of the stem is not dependent on the amount of silica. The true cause of "laying" is the imperfect development of the woody fibres, due to want of light, when corn is sown too thickly.

Assimilation.

The chemical changes taking place during assimilation consist in the decomposition of CO_2 by the chlorophyll corpuscles through the agency of sunlight. The result of this action is an evolution of oxygen gas equal in volume to the carbonic acid gas absorbed; the carbon remains behind, and makes its first visible appearance as small grains of starch within the chlorophyll corpuscles.

The reaction might be represented by the following equation :—

$$6CO_2 + 5H_2O = C_6H_{10}O_5 + 6O_2$$

There are many reasons for thinking that this simple explanation is not sufficient.

The equality in the amount of CO_2 absorbed and O_2 given out, might accompany the formation of formic aldehyde according to the following equation :—

$$CO_2 + H_2O = CH_2O + O_2$$

Formic aldehyde readily undergoes polymerization, so that grape sugar might easily be derived from it.

$$6CH_2O = C_6H_{12}O_6$$
$$\text{and } C_6H_{12}O_6 - H_2O = C_6H_{10}O_5$$

This has not been proved, however; all we know for certain is that a substance is formed which ultimately is converted into starch.

Chemistry of Respiration.

The chemical changes which take place during respiration consist in the absorption of oxygen gas and the evolution of carbonic acid gas and water. This effect can only be observed in the dark, because in the day time it is obscured by the process of assimilation going on, which is exactly the opposite to that of respiration, viz. the absorption of CO_2 and the evolution of O.

The formation of CO_2 and H_2O is the last stage in a series of oxidations always taking place in the tissues. The complex molecules built up by the protoplasm are gradually broken down by the oxygen, the energy absorbed to build them up, derived in the first instance from sunlight, is set free in the form of heat and mechanical energy within the plant.

Chemical Changes connected with Metastasis.

The chemical changes which occur in connection with the nutrition of the plant are very complicated indeed, and very important. We have first to remember that all constructive processes are carried out by the living protoplasm, and in those parts of the plant where the protoplasm is most abundant there we find the greatest amount of chemical change going on; as, for example, the *leaves*, the *growing points*, the *secreting cells*.

We saw that, during the process of assimilation, starch was manufactured within the chlorophyll granule, and it is entirely from this starch within the leaves that the different cells of the tissues derive their supply of carbonaceous material.

Starch, which is insoluble, has to be changed into a soluble body before it can be removed. This is done by converting it into sugar by means of an unorganized ferment, called *diastase*. The sugar is diffusible, and thus can pass through the cell walls dissolved in the sap, and reach those cells where it may be required.

Nitrogenous substances are formed by the protoplasm of the leaf cells from materials absorbed by the roots, such as nitrates, salts of ammonia, etc. The probable action is, that the nitrates are decomposed by the organic acids in the sap, and nitric acid is set free. The nitric acid is used by the protoplasm, in combination with some carbohydrate, and sulphur, and phosphorus, to form proteid substances.

There is little doubt that proteid is not directly formed, but that nitrogenous compounds of less complex composition are formed first, these intermediate compounds being amides, such as asparagin, leucin, etc.

Malting of Barley.

This work is not commonly undertaken by the farmer; it belongs more to the brewer. The latter performs it in the manufacture of alcoholic liquors. The barley is put into large tubs, and soaked with water for 48 hours. It is then taken out and spread evenly upon the floor of a warm room, to the depth of six or eight inches. The room should be kept at a temperature of from 80° to 90° Fahr. The grain has now all the essential conditions of germination, viz. moisture, heat, and oxygen. It accordingly begins to sprout in a similar manner to what it would have done if it had been sown in the ground in the natural course of operations. It continues germinating for about 48 hours, and then the process is stopped by raising the heat of

the room suddenly to 130° or 140° Fahr. This high temperature soon kills the young embryo, and the malt is now screened, by which operation the shoots are separated. The remainder is next steeped in water, by which a part of the sugar is dissolved out, and forms the sweet wort of the brewer. The malt is then of no more use to that person, and is therefore sold to the farmer. It is commonly known as brewers' grains, or draff.

But when the farmer performs the operation, he stops as soon as he has killed the germ, and hence saves much of the soluble sugars. When a large quantity of inferior barley is left on hand, it may often be used to advantage in this manner.

Changes taking Place during Malting.—It is well known that during germination various important chemical changes take place in the seed in order to prepare food for the young embryo. Water is absorbed into the grain, and the young plumule and radicle soon begin to sprout. But during this time they are not gathering up food for themselves, and have to depend upon what has been stored up for them in the seed. The food there, however, is in an insoluble solid form, and hence the need of a chemical change. The starch is acted upon by a ferment called diastase, contained in the nitrogenous part (scutellum) of the seed. It is changed first into dextrin, and then by further action partly into glucose. In this way from 8 to 10 per cent. of the whole grain is changed into a soluble sugar, of great use to the embryo. A small amount of the insoluble albuminoids is changed into amides, in which form it can be taken up by the young plant. These chemical changes are attended by evolution of heat and carbonic acid gas. It has been calculated that from 3 to 6 per cent. of the whole grain is lost as carbonic acid gas, and about 3 per cent. is taken off as the combs, or dust.

The quality of the grain influences the process of malting greatly. Thus, Sir J. B. Lawes found that with barley of fair malting quality there was a loss of 19 per cent. of its weight during the operation; and of this, 12 per cent. was water, and 7 per cent. solid or food material. With a barley of good feeding, but inferior malting, powers, there was a loss of 22 per cent. of its weight; and of this 15 per cent. was water, and 7 per cent. solid matter. An inferior grain must produce poor malt, and the loss of carbonaceous matters in this case would cause the malt to be of very low quality. Again, in well-developed grain the starch would be more quickly acted on by the ferment, and a large percentage of soluble matters would be the result.

Brewers' grains are distinct from malt, and are possessed of low feeding value, having had nearly all their sugar extracted. When a farmer malts his own barley, he only desires to improve

its feeding qualities, and to do this he does not let the malting process go as far as the brewer would, and hence there is less loss of carbon in the form of carbonic acid gas.

Value of Malt as a Feeding Material.—Malt is not used as food as much as might be expected. The farmer rarely takes the trouble to prepare malt; while brewers' grains are not always obtainable, and are rather low in nutritious matters. The analyses given show the composition of barley and malt.

ANALYSES OF GRAIN AND MALT.

	Barley.	Malt Barley.	Wheat.	Malt Wheat.
Moisture	14·8	9·35	13·7	9·68
Oil	2·1	1·97	1·6	1·30
Albuminoids	11·2	11·37	13·2	10·37
Soluble carbohydrates ..	65·5	68·27	66·2	73·26
Woody fibre	5·2	5·53	3·6	2·70
Ash	2·2	3·51	1·7	2·69

The analyses of malt are by Dr. Voelcker.

Wheat is seldom malted, and indeed is not often used as food for the stock at all.

Malt owes its higher feeding value to the fact that most of its constituents are in a soluble form. With enough heat all its carbohydrates will become digestible. Not only is this the case with the malt, but, according to Sir J. B. Lawes, should other grains be mixed with the malt, and the digestion assisted by heat, most of their starchy matters will become readily available. This action is a very important one, and shows that it would be an advantage to mix a little malt with the food of nearly all kinds of stock.

Malt contains from 5 to 10 per cent. less water than barley grain, and also often has a somewhat higher albuminoid ratio. But a given weight of barley gives as good, if not better, results as a rule than the amount of malt produced from a similar quantity. This is owing to the amount of matter lost during the process of malting.

Malt is very palatable and acts as a condiment to a certain extent. All stock eat it readily, and it is very useful as a food for animals in rather delicate health. It also tempts the fat cattle to eat freely, when otherwise they very often have no appetite for their food. Malt is very useful for putting a finishing touch upon fatting stock, and for getting young animals into good condition.

The benefits derived from the use of malt vary a good deal according to the character of the animal. It has been found that strong healthy stock give the best results. Weakly creatures, although greatly assisted in being restored to good condition, did not thrive so well upon the food. With regard to milking cattle, the produce was almost alike, but rather more cream was got from the milk of the cows fed on a similar amount of ordinary barley.

According to Mr. F. Beard in the *Journal of the Royal Agricultural Society*, 1881, the cost of malting barley is about 2*s.* per quarter. This expense detracts somewhat from the value of the malt, but the authority just stated says that the result amply repays the outlay. For cattle he ground the malt up, mixed it with chopped straw and hay, and then added enough pulped roots to ferment the whole in 24 hours. 1 gallon malt meal, a few pounds of linseed cake- and barley-meal, and the above mixture *ad lib.* was given to each cow. Sheep in folds should get about 2 lbs. of ground malt, barley, and linseed-cake in equal proportions.

Mr. James Howard, in the same journal, says he gave each of his working horses 1½ bushels oats, 1 peck maize, 1 peck malt, and 14 lbs. bran weekly, besides hay. The oats, maize, and malt were crushed. Young horses got 1½ lbs. malt a day, with 3 pecks oats, and 14 lbs. bran weekly, besides hay or grass. Wether sheep on roots had ½ lb. malt, ½ pint maize, and 1 pint tail barley daily. His lambs got small amounts of malt when a month old. Feeding bullocks had 2½ to 4 lbs. malt, 1 gallon meal, 1 gallon linseed and cotton cake per day. He says that it is best to begin with small amounts, and then to slowly and gradually increase.

Malt-combs.—These are sometimes known as malt cummins or malt-dust. They consist of the separated radicles and plumules of the malting barley.

ANALYSES OF MALT-COMBS (DR. VOELCKER).

Moisture	10·83	5·74	11·54
Albuminoids	23·81	21·94	26·81
Non-nitrogenous organic matter	58·70	66·12	56·31
Phosphates of lime and magnesia	1·49	1·97	
Alkaline salts	4·06	2·40	5·34
Insoluble silicious matter	1·11	1·83	

The above authority says that malt-combs are a very good food for milk cows, at the rate of 2½ lbs. per day, containing as they do

large amounts of all required constituents, especially phosphates. He also recommends it for sheep. Some farmers use the malt-combs as manure, but this is a wasteful practice, as they contain much soluble sugar and other matters, of no use to the plant. Should they be very dirty they may be added to the manure-heap.

Malt-combs assist in the digestion of other foods in a similar manner to malt. It is advisable to mix the two together; the resulting mixture is a very good food.

Brewers' Grains.—These consist of malt after it has had as much as possible of its sugar extracted by the brewer. This is done by mashing it in a large vat, and then adding water or steam.

The following analysis shows that they contain a large percentage of water, and consequently are very much less valuable as food than malt:—

Water	76·7
Albuminoids	4·8
Fat	1·2
Soluble carbohydrates	11·1
Fibre	5·0
Ash	1·2
	100·0

By a certain process brewers' grains can be dessicated or dried. This reduces the bulk greatly, and lowers the cost of carriage, but against this there is the expense of drying, which has to be done by artificial means.

Brewers' grains, being very succulent, and stimulating to the mammary gland, greatly increase the flow of milk, and hence are often used in dairies, the cows getting up to half a bushel a day. The milk is rather deficient in solid matters, but where the milk is sold it pays to use them.

D.—*Chemistry of the Animal Body.*

Composition of the Animal Body.

The primary substance of all animals is *Protoplasm*, or Bioplasm (Life-substance). The other organic bodies which are afterwards produced are formed from the metabolism of this protoplasm.

The exact chemical formula of protoplasm has never been made out, as it seems to be constantly subject to change, and

even the percentage composition cannot be satisfactorily given, for the same reason. It is known that protoplasm contains carbon, hydrogen, oxygen, and nitrogen, with small amounts of sulphur and phosphorus. It appears that protoplasm consists of a network of dead proteids, incapable of solution in caustic alkalies, and known as plastin, and of a true living portion, soluble in potash.

The derivatives of protoplasm may be roughly classed under three heads: (1) Proteids; (2) Carbohydrates; (3) Fats and Oils.

Proteids.—These form the greater part of the muscular and nervous tissues. Hoppe-Seyer says the composition is as follows: C, 51·5 to 54·5%; H, 6·9 to 7·3%; N, 15·2 to 17%; O, 20·9 to 23·5%; S, ·3 to 2%. In addition to these, most proteids contain a small variable amount of ash, probably due to the admixture of other bodies.

Tests.—Red precipitate on heating with Millon's reagent. Heated with strong nitric acid they turn yellow; on the addition of ammonia the colour changes to deep orange. With a caustic soda solution, a violet colour is obtained with one or two drops of copper sulphate; the colour deepens on boiling.

Proteids are divided up into the following classes:—

Class I., Native Albumins.—Naturally occurring bodies, soluble in water, precipitated by very dilute acids, and by common salt, coagulated by heating to about 70 degrees.

1. *Egg-albumin.*—Forms the greater part of the white of egg. It is coagulated by strong acids, and by excess of strong alcohol. In an aqueous solution it is a neutral, transparent, slightly yellow fluid.

2. *Serum-albumin.*—Found in the blood, lymph, and serous excretions, etc. When dried it is a yellowish, brittle, transparent body, soluble in water. It may be distinguished from the previous albumin by not being coagulated by ether.

Class II., Derived albumins.—These bodies are insoluble in water, but readily soluble in alkalies or dilute acids. They are not coagulated by heat.

1. *Acid-albumin.*—By the action of a dilute acid on a native albumin in solution, at a fairly warm temperature, acid-albumin is formed. It now becomes insoluble in water and uncoagulable by heat. By treating finely divided muscular tissue with dilute hydrochloric acid, from which all the soluble albumins have been washed, a considerable quantity of the muscle may be dissolved. The filtrate contains a proteid, resembling acid-albumin, but known as *syntonin.* During digestion in the stomach a somewhat similar body is formed by the gastric juice from the lean part of meat.

2. *Alkali-albumins.*—Should an alkali be used instead of an acid as above, alkali-albumins result. They greatly resemble the previous bodies.

3. *Casein.*—Found in milk, and forms the chief constituent of cheese. In its properties it greatly resembles the alkali-albumins. It may be obtained from milk by adding dilute acetic acid, as a white, friable, opaque body.

Class III.—Globulins.—Native proteids insoluble in pure water, but soluble in dilute solutions of acids and alkalies. They are coagulated by heat, and precipitated from solutions by alcohol.

1. *Globulin, or Crystallin.*—Obtained from the crystalline lens of the eye. It is precipitated by carbonic acid and by alcohol.

2. *Paraglobulin.*—Known also as Fibrinoplastin. It can be precipitated from blood-serum by carbon dioxide, or, to a less extent, by common salt. In water containing no oxygen, paraglobulin is insoluble.

3. *Fibrinogen.*—This also is found in the blood, and greatly resembles paraglobulin. When mixed with the fibrin-ferment, fibrinogen develops fibrin, the chief substance in the clot of blood.

4. *Myosin* is the chief constituent of muscle when undergoing "rigor mortis." When moist it is an elastic, gelatinous mass; when dry, it is very brittle. It may be precipitated from a solution by common salt; but is very soluble in dilute acids and alkalies.

5. *Vitellin.*—Obtained from the yolk of eggs, and from the crystalline lens of the eye. It is not precipitated by sodium chloride, and is soluble in dilute acids, being in this manner readily converted into syntonin.

Class IV.—Fibrin.—The fibrins are solid albuminous bodies, insoluble in water and dilute common salt solutions, and almost insoluble in dilute acids and alkalies. When treated with acids they swell up into a stiff jelly. Fibrin may easily be obtained from blood, which has been diluted with an equal bulk of water, by whipping with twigs. It rapidly coagulates on the twigs in white stringy masses.

Class V.—Coagulated Proteids.—These are very insoluble bodies, only being dissolved by strong acids and alkalies. They are produced by heating native albumins to about 70 degrees. By the action of gastric or pancreatic juice in the ordinary processes of digestion they are converted into peptones.

Class VI.—Peptones.—These bodies, as stated before, are produced during the digestion of proteids. They are extremely soluble in water, and are not precipitated by the action of acids

or alkalies, or by boiling. They are insoluble in alcohol, and are with difficulty precipitated by it. They are, however, precipitated by the bile-acids.

Class VII.—Lardacein.—Lardacein appears to be derived from fibrin, and is found as a deposit in liver, spleen, kidneys, etc. It is insoluble in water, ether, alcohol, dilute acids, and the digestive juices. It gives a violet solution on boiling with sulphuric acid, and with the strong acid is converted into tyrosin and leucin. Its composition is much the same as that of other proteids, but it appears that the sulphur exists in an oxidized state.

Nitrogenous Bodies allied to Proteids.

Under this head may be considered the non-crystalline albuminoids.

1. *Mucin.*—Found in all mucous secretions. Its approximate composition is C, 48·94%; H, 6·81%; O, 35·75%; N, 8·50% (Eichwald). It is of a glutinous nature, and will not dissolve in water. It dissolves in concentrated mineral acids. It gives the same reactions as proteids with Millon's reagent and with nitric acid, but not with copper sulphate.

2. *Gelatin, or Glutin.*—Formed by the prolonged boiling of connective tissues in water, or by heating for a lengthy period in dilute acetic acid. Its percentage composition is C, 50·76; H, 7·15; O, 23·21; N, 18·32; S, 0·56.

The ordinary form of gelatin is well known. It is insoluble in alcohol and ether, but soluble in warm glycerin.

3. *Chondrin.*—Results from the prolonged boiling of cartilage in water; on cooling, chrondrin gelatinizes out as a stiff jelly, which, when dry, forms a hard, translucent, yellowish, gummy mass. Its percentage composition is C, 47·74; H, 6·76; O, 31·04; N, 13·87; S, ·60. It can be easily dissolved by hot water, ammonia, and the alkalies, and precipitated from its solutions by acetic acid and dilute mineral acids.

4. *Elastin* may be obtained from yellow elastic fibre, as in the ligamentum nuchæ, for instance. It is soluble in strong boiling alkalies, and in concentrated nitric and sulphuric acids. It is made up of 55·5% C, 7·4% H, 20·5% O, 16·7% N.

5. *Keratin* is found in horn, feathers, hair, etc. Continued boiling with acids and alkalies dissolves it. On treating the acetic solutions with an acid, sulphuretted hydrogen is evolved. Its percentage composition varies thus: C, 50·3 – 52·5; H, 6·4 – 7·0; O, 20·7 – 25·0; N, 16·2 – 17·7; S, 0·7 – 5·0 (Foster). It differs greatly from the proteids in its properties.

6. *Nuclein* ($C_{29}H_{49}N_9P_3O_{22}$).—This is found in the yolk of egg. It is soluble in alkalies, and gives a precipitate with copper sulphate.

7. *Collagen* forms the organic base of bones and teeth, and of the fibrous part of tendons and ligaments. It is insoluble in cold water. When acted on by dilute acids it first swells and becomes transparent; with prolonged action it dissolves.

Carbohydrates.—These never contain nitrogen. The greater part are vegetable, but a few, to be mentioned here, are normally found in animal tissues, etc.

1. *Dextrose*, or Grape Sugar ($C_6H_{12}O_6 + H_2O$).—In the animal body it occurs in the blood, lymph, chyle, liver, etc. Its chemical properties have been treated in the section on the "Constituents of Plants."

2. *Lactose*, or Milk Sugar ($C_{12}H_{22}O_{11} + H_2O$).—Occurs in milk to the extent of about 4½ per cent. On heating lactose to 100° C, it loses its extra molecule of water. It can be crystallized in the form of hard, colourless, rhombic crystals, insoluble in alcohol or ether, but dissolving in water. Under the action of an organized ferment, the *Bacterium lactis*, lactose changes to lactic acid.

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} + H_2O = \underset{=\text{ lactic acid.}}{4\ C_3H_6O_3}$$

3. *Maltose* ($C_{12}H_{22}O_{11} + H_2O$).—This sugar is produced by the action of a diastasic ferment, or of dilute acids on starch.

4. *Inosite* ($C_6H_{12}O_6 + 2H_2O$).—Occurs in the animal body in the heart-muscles, and in most of the organs of the body, especially of the horse and cow. It crystallizes in long, efflorescent, rhombic tables. It is insoluble in alcohol and ether, but readily soluble in water. It cannot undergo alcoholic fermentation.

5. *Glycogen* ($C_6H_{10}O_5$).—Glycogen may be obtained from the liver as a white amorphous powder, forming an opalescent solution. Under the action of various ferments it is converted into dextrose.

With iodine, glycogen gives a port-wine colour, which disappears on heating. In this it resembles dextrose, but on cooling the glycogen solution, the colour returns.

6. *Dextrin* ($C_6H_{10}O_5$).—May be formed from starch by the action of ferments. It is soluble in water, but precipitated by alcohol. It does not undergo alcoholic fermentation.

The Fats and their Derivatives.—To go fully into all this series would take up too much space, consequently only the more important can be given. Many of the fats consist of compounds of glycerin and various fatty acids, and rarely contain nitrogen or sulphur.

1. *Palmitin* ($C_3H_5[OC_{16}H_{31}O]_3$).—Palmitic acid ($C_{16}H_{32}O_2$). Melts at 45° C. Crystallizes in fine needles. It is more soluble in ether and alcohol than stearin.

2. *Stearin* ($C_3H_5[OC_{18}H_{35}O]_3$).—Stearic acid ($C_{18}H_{36}O_2$). This is the chief constituent of the more solid fats, as mutton suet. Melts between 53° and 66°. Insoluble in cold ether and alcohol, but soluble in both when boiled. Crystallizes in square tables.

3. *Olein* ($C_3H_5[OC_{18}H_{33}O]_3$).—Oleic acid ($C_{18}H_{34}O_2$). Fluid at ordinary temperatures, solidifying below 1°. Found in pig's fat.

4. *Glycerin* ($C_3H_5[OH]_3$) is a thick, colourless syrup. When cooled sufficiently, it solidifies, forming crystals like sugar-candy. Soluble in water and alcohol; insoluble in ether.

The four preceding bodies are found among the butter fats of milk; in addition to them we have triglycerides of the following fatty acids.

Butyric acid ($C_4H_8O_2$).—Butyrin ($C_3H_5(OC_4H_7O)_3$). The acid is an oily liquid, supposed to give the odour of rancid butter, owing to its being set free from butyrin. Soluble in water, alcohol, and ether.

Myristic acid ($C_{14}H_{28}O_2$), *Caproic acid* ($C_6H_{12}O_2$), *Caprylic acid* ($C_8H_{16}O_2$), and *Capric acid* ($C_{10}H_{20}O_2$), are also found in butter the last three being volatile fatty acids.

Cholestrin ($C_{26}H_{44}O[H_2O]$) is found in the bile. It is a white, crystalline body, forming the greater part of "gall-stones."

Nitrogenous Fats.—These are several fatty bodies, containing nitrogen, and found in the brain, etc.

Lecithin ($C_{44}H_{90}O_9NP$) is a phosphorized fat, occurring in small amounts in many organs of the body, and found as well in the white blood corpuscles. It is a colourless substance, soluble in ether, alcohol, carbon disulphide, etc. It is easily decomposed, one of the products being stearic acid.

Protagon, a body whose exact composition is not known, occurs in the brain.

Chemistry of Digestion.

Salivary Digestion.—Saliva is a fluid secreted by certain glands in the cheeks, and effects the first chemical change in the food.

Composition of Saliva (Lassaigne).

Animal.	Specific Gravity.	Water.	Mucus and Albumen.	Alkaline carbonates.	Alkaline chlorides.	Alkaline Phosphates, and Phosphates of Lime.
Horse	1·0045	99·2	0·2	0·108	0·492	traces
Cow	1·010	99·074	0·044	0·338	0·285	0·259
Sheep		98·9	0·1	0·3	0·6	0·1

The most important constituent of saliva is ptyalin, a ferment, which converts starchy substances into sugars. The exact manner in which this is done is not known, but two theories as to the products have been advanced.

$$(1)\quad \underset{\text{Starch and water yield}}{3C_6H_{10}O_5 + 3H_2O} = \underset{\text{grape sugar}\ +}{C_6H_{12}O_6} + \underset{\text{dextrin.}}{2C_6H_{10}O_5 + 2H_2O}$$

$$= 3(C_6H_{12}O_6)$$

$$(2)\quad \underset{\text{Starch and water yield}}{20(C_6H_{10}O_5) + 8\,H_2O} = \underset{\text{maltose}}{8(C_{12}H_{22}O_{11})} + \underset{+\ \text{achroödextrin.}}{2(C_{12}H_{20}O_{10})}.$$

Whatever results, however, the amylaceous compounds are rendered more soluble.

Gastric Digestion.—The process of digestion in the stomach is effected chiefly by the gastric juice. The composition of this substance in the sheep and dog is as follows :—

	Dog.	Sheep.
Water	96·10	98·39
Organic matter (especially ferments) ..	1·67	0·40
Sodium chloride	0·22	0·42
Calcic chloride	0·02	0·01
Potassic chloride	0·10	0·15
Ammonium chloride	0·04	0·04
Free hydrochloric acid	1·67	0·40
Calcic phosphate	0·16	0·11
Magnesic phosphate	0·02	0·05
Ferric phosphate	——	0·03
	100·00	100·00

The chief ferment in the gastric juice is pepsin, a nitrogenous principle. Unlike ptyalin, which only performs its work in alkaline solutions, pepsin effects its changes in acid solutions alone. It may be noticed in the above analyses that free hydrochloric acid is present. Small amounts of lactic, butyric, and other acids may be found, but these may be classed as products of decomposition of the food.

The exact changes caused by pepsin are not very well-known. It appears that it transforms proteids into soluble peptones, which may then be absorbed by the walls of the stomach. Gastric juice coagulates the casein of milk, consequently "rennet," an infusion of calves' stomachs is used in cheese-making. This action is not

due entirely to the acid, as neutralized gastric juice is efficacious. It is supposed to be due to a milk-curdling ferment contained in the gastric juice.

Pancreatic Digestion.—Pancreatic juice is a clear viscid fluid, with a very decided alkaline reaction. In the dog it contains from 91 to 98 per cent. water, and 9 to 1½ per cent. of solids, of which 9 to 1 per cent. is organic matter.

Pancreatic juice contains three principal ferments, Trypsin, Amylosin, and Steopsin.

Like gastric juice, trypsin converts proteids into peptones, but considerable amounts of other bodies also appear. Of these latter substances, leucin ($C_6H_{13}NO_2$), and tyrosin ($C_9H_{11}NO_3$), two crystallizable nitrogenous bodies, are the chief.

Amylosin has no action of any consequence upon proteids, but can dissolve carbohydrates. In the changes it causes, there is a great resemblance to those due to ptyalin, except that the action of the saliva is less vigorous.

Steopsin attacks the fats of foods, splitting them up into the fatty acid and glycerin. The fatty acids thus liberated combine with the alkaline bases of the pancreatic juice and bile to form soaps. These soaps further assist the steopsin and bile in forming an emulsion of the fats and oils. In this state the villi on the walls of the duodenum are able to absorb the fatty food materials.

The changes may be represented thus:—

$$(1)\quad \underset{\text{Palmitin}}{2C_3H_5(OC_{16}H_{31}O)_3} + \underset{\text{water}}{6H_2O} = \underset{\text{palmitic acid}}{6C_{16}H_{32}O_2} + \underset{\text{glycerin}}{2C_3H_5(OH)_3}$$

$$(2)\quad \underset{\text{Palmitic acid}}{C_{16}H_{32}O_2} + \underset{\text{potassic hydrate}}{KHO} = \underset{\text{potassic palmate or soap}}{C_{16}H_{31}O_2K} + \underset{\text{water.}}{H_2O.}$$

Bile.—The specific gravity varies from 1·008 to 1·030. A sample from a pig was found to contain 88·8 per cent. water, and 11·2 per cent. solids. Of the solids, 7·3 per cent. was bile salts, 2·2 per cent. fats and soaps, ·6 per cent. mucin and colouring matter, and ·11 per cent. ash. Its reaction is alkaline. The bile salts consist principally of glycocholate and taurocholate of soda. Glycocholic acid possesses the formula $C_{26}H_{43}NO_6$. It may be decomposed by boiling with H_2O into cholic acid and glycin, thus:—

$$C_{26}H_{43}NO_6 + H_2O = \underset{\text{Cholic acid}}{C_{24}H_{40}O_5} + \underset{\text{glycin.}}{C_2H_5NO_2.}$$

Taurocholic acid ($C_{26}H_{45}NO_7S$) is derived from the breaking down of albuminoids. It may be split up into cholic acid and taurin ($C_2H_7NSO_3$).

In action bile seems to assist the amylosin of pancreatic juice in forming an emulsion of fat. It also tends somewhat to preserve the food in the intestines from decomposition.

Succus Entericus.—This is a digestive juice secreted by the Lieberkühnian follicles. It is of a slightly alkaline nature, and contains nearly 99 per cent. water. Its use is scarcely known, but it is supposed to convert cane-sugar into dextrose, and laevulose, thus :—

$$C_{12}H_{22}O_{11} + H_2O = C_6H_{12}O_6 + C_6H_{12}O_6.$$

Saccharose + water = dextrose + laevulose.

The Chemistry of Excretion.

Intestinal secretion may be almost disregarded in the present section, as the composition of the fæces, etc., is dealt with in the chapter on "Manures."

Renal Secretion.—This is really made up of two acts : (1) the mere infiltration of various constituents, as water, sugar, peptones, and certain salts, into the glomeruli; and (2) the manufacture of others in the kidneys from bodies originally existing in the blood. The physiological part of renal secretion is dealt with under the "Anatomy of Farm Animals." At present, only the chemistry will be touched.

(Composition of Urine Boussingault).

	Horse.[1]	Cow.[2]	Pig.[3]
Water	91·00	92·12	97·91
Urea	3·10	1·85	0·49
Alkaline lactates	2·01	1·72	——
Potassium bicarbonate	1·55	1·61	1·07
Calcic carbonate	1·08	0·06	traces
Potassic hippurate	0·47	1·65	——
Magnesic carbonate	0·42	0·47	0·09
Potassium sulphate	0·12	0·36	0·20
Sodium chloride	0·07	0·15	0·13
Silica	0·10	traces	0·01
Phosphates	——	——	0·10
	99·92	100·00	100·00

According to R. M. Smith, the water, K, Na, Ca, and Mg, compounds are derived directly from the blood. The sulphuric acid results from the oxidation of sulphur compounds in the food;

[1] Diet of oats and clover-fodder. [2] Diet of hay and potatoes.
[3] Diet of cooked potatoes.

the phosphates, from the oxidation of albuminoids in the food and tissues; carbonates, from the food, and also from the decomposition of vegetable acids.

Urea ($CO[NH_2]_2$) results from the decomposition of albuminoids. Small amounts may already exist in the blood, but the greater part is formed in the kidneys.

Uric acid ($C_5H_4N_4O_3$) is formed in the same manner as urea. It is rarely found in the urine of mammals, but occurs in that of birds and serpents.

Kreatin ($C_4H_9N_3O_2$) is not a normal constituent of urine, but may occur there owing to the conversion of kreatinin into it. It may be decomposed into urea, etc., thus:—

$$C_4H_9N_3O_2 + H_2O = \underset{\text{Sarcosin}}{C_3H_7NO_2} + \underset{\text{urea.}}{CO(NH_2)_2}.$$

Hippuric acid ($C_9H_9NO_3$) is a combination of benzoic acid with glycochol. It originates in the constituents of vegetable foods, the cuticular portions of which develop benzoic acid.

It may be noticed that the urine of the pig alone contains phosphates.

Epidermal Excretions.—*Sweat* is, of course, the chief substance to be noted here. It is commonly of either a neutral or an alkaline nature, though sometimes it is acid. This latter characteristic is due to the development of fatty acids from decomposition of the fatty materials of the sebaceous glands.

Sweat contains about 1·8 per cent. solids, of which two-thirds are inorganic, and consist chiefly of alkaline chlorides. Small amounts of urea are also present.

Sebaceous secretions consist chiefly of fats or oils, with small amounts of albuminous matter, water, cholestrin, and ash (potassium salts principally). They are formed from the metabolism, or breaking down, of protoplasmic matter in the sebaceous glands.

In connection with the sebaceous secretions we may notice the "*suint*" of wool, which, together with other fatty products, forms the "*yolk*." Suint is a compound of potassium with an organic acid, containing nitrogen, of which little is known. It is a soluble body, and therefore it is in great part removed by washing. According to Warington, suint may amount to half the weight of the unwashed fleeces of merino sheep; but in sheep that have to stand wind and rain, the quantity may be 15 per cent., or less. Besides this, there is the ordinary fat of the wool, varying from 8 to 30 per cent. of the fleece.

Chemistry of Respiration.

Air, before being taken into the lungs, contains—oxygen, 20·8 per cent.; nitrogen, 79·1 per cent.; carbon dioxide, ·04 per cent.; together with variable amounts of moisture, and traces of ammonia, etc.

Of these substances the nitrogen plays no active part, merely diluting the oxygen. The carbon dioxide also is of no use in respiration. Consequently the oxygen is left alone to perform all changes.

During an inspiration the oxygen of the air comes into close contact with the blood in the minute capillaries of the lungs. The red corpuscles of blood, as mentioned elsewhere, contain a body known as hæmoglobin, the percentage composition of which is C, 53·85; H, 7·32; N, 16·17; O, 21·84 S. ·39, Fe, ·43; with 3 or 4 per cent. of water of crystallization. It has been attempted to give it a formula, thus: $C_{600}H_{960}N_{154}FeS_3O_{179}$. Hæmoglobin in reality consists of a mixture of hæmatin and globulin. Hæmatin by itself is a dark brown amorphous powder, having the probable composition $C_{32}H_{34}N_4FeO_5$. This body performs the most active chemical function of respiration, but only on account of the iron it contains. By means of the iron, the hæmatin forms a sort of loose chemical combination with the oxygen of the inspired air.

The blood after this flows back to the heart, and thence through all the tissues of the body. Here another change occurs. The oxygen is somehow or other taken up by the cells of the muscle, etc., and replaced in the hæmoglobin by carbonic acid gas. The oxygen is used up in the various processes of oxidation, chiefly of carbon compounds, the result of which are the different forms of energy. Hence we see how the carbonic acid gas is obtained.

While the blood contains oxyhæmoglobin it is scarlet in colour, but when charged with carbon dioxide, it becomes more of a purple hue.

In the lungs the CO_2 is turned out of the blood by the oxygen, and the whole process recommences.

Dry expired air will be found to contain about—

Oxygen.	Nitrogen.	Carbon Dioxide.
16·03%	79·55%	3·8%

It is also well saturated with moisture. Many organic bodies, derived probably from the decomposition of materials entering into the composition of the tissues, are also present. Among these may be classed ammonia. It is chiefly on account of these organic substances that the air of rooms crowded with people or animals has such bad effects.

CHAPTER IV.

AGRICULTURAL BOTANY.

A.—*Structure and Physiology of the Plant.*

THE VEGETABLE CELL.

Plants as well as animals commence life as single cells, and in the beginning all these cells appear so much alike that no difference can be detected in them either by chemical or microscopical means.

The embryo cell which produces a blade ot grass presents the same appearance as that which gives rise to an oak tree or develops into a fly, fish, bird, or dog. In the course of development this resemblance soon disappears.

The simplest forms of vegetable life commence as a single cell and remain as such throughout their existence, multiplying by simple division, while the higher plants form colonies which differ in structure from the parent cell. It will be interesting to examine the structure of these simple one-celled plants, because by so doing we get a better idea of the structure and physiology of those which are higher and more complicated. Attention should, therefore, be directed to the yeast-plant, and the common green mould found on the trunks of trees and damp palings.

These may be taken as specimens of two great divisions of plants: first, those which are colourless, like the yeast, and are called fungi; and second, those which contain green colouring matter, like the green mould.

More advanced plants will be found consisting of either a number of cells joined end to end, and forming long chains or threads, as in the case of green algæ, like the spirogyra, and the mycelium threads of fungi, or united together to form a more or less compact mass.

In the simplest forms these cells all resemble one another, but as we ascend in the scale of vegetable life we find that some gradually become altered in shape and chemical composition, so that we have several sets of cells, each set carrying on a special

function. The development of the higher plants from the simple ones may very well be compared with the development of a civilized race from the savage state. In the barbarous condition man has to do everything for himself, with his hand against every man and every man's hand against him; but when men combine to help one another and divide the work between them, every operation is done better. One man attends solely to cultivating the ground, another to making clothes, another to baking bread, etc. The result is a combination for mutual benefit. It is the same with the higher plants, every one of which, in the first instance, starts as a simple cell, primarily dividing up into a large number of similar cells, which then become specialized. They begin to perform special work, and their structure alters so as to especially suit the functions they have to perform. Some on the outside of the plant take on the office of protection; these are the epidermal cells. Their walls become toughened and thickened, and some of them grow out into prickles, or form a hairy coat to protect from the cold, or secrete resinous juices to keep away insects. Others become elongated and their walls thickened so as to give strength and tenacity to the root and stem. These elongated cells placed end to end form the fibres of the flax and hemp.

Other cells form vessels for the conveyance of water from the roots to the leaves. Some form storehouses for nourishment, as in the potato. Others in the leaf become distinct chemical laboratories, where the green chlorophyll granules are busy decomposing carbonic acid gas by the aid of sunlight, and manufacturing starch and sugar in a way that has as yet defied the most able chemists to discover.

We may then look upon the higher plants as colonies of highly specialized cells, united together and working for their mutual benefit, each having its particular function to perform, and doing its duty in a mechanical and unvarying manner, unless prevented by disease from accomplishing it.

Each passes through the various stages of its life history, performs its functions, and dies without interfering with the general welfare of the plant of which it forms a part. Indeed, many cells do not begin to be of service to the community till after their death; such, for instance, are those forming vessels and woody fibres.

The cell, then, is the basis of the structure of all plants; consequently, it is necessary to get a very clear idea of its structure and composition, as well as of its contents.

In all cells, at some time during their growth, the following structures may be made out :—

1. The wall, consisting of cellulose.

2. A granular, sticky substance, protoplasm, lining the wall.

3. Imbedded in the protoplasm is the *nucleus*, a specialized part of the protoplasm.

4. The sap, a watery fluid filling the interior more or less.

It will be seen that the young cells change very much as they get older. In their early condition they are comparatively small, the wall is very thin and the protoplasm dense, filling up the whole of the interior. As the cell gets older, the walls thicken; the sap, which at first is distributed through the protoplasm, collects in small drops, called vacuoles. As it increases in size, the drops of sap coalesce and fill the central space, while the protoplasm retreats to the wall, where it forms an investing layer. If the cell forms part of the succulent portion of the plant, it remains in this condition; but if it belongs to a set forming tissue vessels, cork, etc., still further changes take place. It may change its shape, may become very much elongated, the walls thickened, and their chemical nature altered, the protoplasm disappears, and the cell may contain only water or air.

Protoplasm generally presents itself as a granular semi-fluid substance with or without a cell wall.

It must always be remembered that the only living part of the cell is the protoplasm, and as the whole plant is composed of cells, it follows that protoplasm is the only living part of the plant.

Upon more careful examination, protoplasm is found to consist of a fine network, enclosing a more fluid substance in its meshes, and that its consistency varies with the size of the meshes. Animal and vegetable protoplasm are almost exactly the same in composition. We therefore refer the reader to p. 114.

Concerning the nature and composition of starch, cellulose and chlorophyll, the student should refer to the chapter on the chemical composition of plants.

The Growing Point.—If a longitudinal section of the growing point of any young plant (the radicle of the bean, for example) be examined under the microscope, it will be found that the structure consists of a number of cells separated from one another by walls, and containing protoplasm and cell sap.

At the apex will be found a number of cells all alike, with very thin walls. These are capable of dividing by transverse division, and in this way the root or stem increases in length, but of those left behind only a small number retain the power of multiplication, and they form a cylindrical ring of cells between the bark and the wood. This is called the *cambium layer*.

It is by the growth of these cells every summer that trees

increase in thickness. Grasses and other plants belonging to the class of monocotyledons have no cambium layer, and do not increase in thickness every year.

The remaining cells become altered as they get older. They have all different functions to perform, and their structure becomes modified accordingly.

Epidermis.—The outside cells become *epidermal cells*. Their function is protective, therefore their walls become thick, tough, and impervious to water, the contents disappear, and they become filled with air, or become solid and hard, forming prickles.

Vessels.—Some of the cells join together end to end, and the partitions between them being absorbed, they become vessels. Some of them have special thickenings. The vessels of the wood serve for the rapid ascent of the crude sap to the leaves during transpiration.

Woody Fibres.—Others, again, become very much elongated, the walls greatly thickened, and the cellulose is converted into lignin. In this way woody fibres are formed.

Some cells act as reservoirs for starch and oil, as in the potato and linseed.

Structure of the Root.—The root is, as a rule, the underground portion of the plant, but as exceptions to this it may be stated that some stems, as of the potato, are underground, and some roots, as of ivy and some orchids, are aërial. The root is of a brownish colour usually, owing to the non-development of chlorophyll in its tissues. The main root is commonly known as the tap root; from this, in dicotyledons, others branch off approximately at an angle of 45°. After this the order becomes somewhat irregular. The extremities of the rootlets are protected by a root-cap (pileorhiza) made up of thickened cells. It is immediately behind this cap that increase in length takes place, and this also is the only point for assimilation.

Increase in width is caused by the action of the cambium layer, which lies just beneath the cortex, or part usually classed as bark. Fresh rootlets are also immediately derived from the cambium layer, which forms outgrowths that push their way through the epidermis.

Forms of Roots.—In monocotyledons, *e.g.* grasses, cereals, etc., the chief form of root is fibrous—that is, a number of slender branches are given off without any definite tap. When these fibres become swollen we get tuberculated forms, as in some orchids; or nodulose, as in dropwort. As examples of simple tap root we may take the oak. Sometimes the taps take peculiar forms, and then receive distinctive names: when broad at the base and tapering to a point, as in the carrot, it is called *conical;*

if broadest in the centre, as in the radish, *fusiform;* when globular, as in the turnip, it is known as *napiform.*

Functions of the Root.—(1) To hold the plant in the ground.

(2) To assimilate nourishment. This is the chief function. The substances absorbed consist of various salts in very dilute solution, and only in this form can plants take up their mineral food. The solution diffuses through the thin cell walls of the root-hairs, immediately behind the root-cap. At no other point can the process take place. The solution then passes from cell to cell, according to the law of osmosis, or rises rapidly through the vessels of the wood to the leaves as crude sap. This rapid movement of the crude sap only occurs during the process of transpiration from the leaves, consequently it cannot take place during winter, when the leaves have fallen.

It must not be supposed, however, that the water in the soil has all the plant-food constituents ready in solution, and that the root has simply to absorb it. Many substances, especially phosphoric acid, are rarely found in solution in the soil, and it seems that the root-hairs themselves have to come in very close relationship with the particles of the soil before they can obtain the supplies of nourishment which are held in loose chemical combination by some of the constituents of the soil. The acid sap that plants exude apparently dissolves phosphates and carbonates of lime and potash, so that they can be absorbed with the crude sap. This can be easily proved by germinating seeds on a piece of polished marble, covering them with a very thin layer of moist sand. It will be found, after a time, that the young roots have corroded the surface of the marble, dissolving out the carbonate of lime, and leaving minute grooves where they have been in contact.

(3) To store up nourishment. This function is not carried out by all plants; but in the turnip, carrot, radish, mangel, etc., we see very good examples. The sap, after being elaborated in the leaves, descends to the root, and there many of the substances it held in solution are deposited. They are used up by the protoplasm to build and fill fresh cells. Starch is the chief material stored up in this manner.

Where this function is carried out, it usually shows that the plant is a biennial—that is, it stores up nourishment one year to serve as food during the flowering process next year.

Structure of the Stem.—The stem has several distinctions from the root: (*a*) it may develop chlorophyll, (*b*) may possess stomata, (*c*) never has a root-cap, (*d*) may produce leaves.

We will briefly notice the various component parts of a typical dicotyledon stem; as of an oak, for instance. In the centre we

have the pith, consisting of dead cells more or less filled with air, and serving no function. Next to them in order outwards is the xylem, which forms the wood. It consists of vessels, sieve-tubes, and fibres, and, in a tree, is seen to be divided up by a number of circular "annular" rings. Outside the xylem is the cambium ring, consisting of meristem tissue—that is, tissue capable of growth. This is the only growing part of the stem. When the bark is peeled off a live twig in spring, the cambium layer is the sticky surface met with.

After the cambium layer comes the phloëm, consisting of sieve-tubes and fibres. This forms a small ring just under the bark. Lastly, we have the bark made up of epidermis, subepidermis, and cortex. All thorns, hairs, etc., belong to the epidermis.

From the cambium layer there proceed inwards a number of tubes, known as medullary rays, which carry nourishment into the xylem.

Forms of Stems.—Stems may be erect, creeping, climbing, twining, or underground. Among creeping stems we have the varieties of runner (strawberry), offset (houseleek), stolon (gooseberry), rhizome (Solomon's seal).

Functions of the Stem.—(1) To bear leaves and flowers.

(2) To carry nourishment from the root to the leaves to be elaborated. The crude sap ascends by the xylem, and descends by the phloëm. It ascends by the aid of the vessels and sieve-tubes; the parts of the stem are supplied through the medullary rays, or by passage from cell to cell.

(3) To store up nourishment.

Structure of the Leaf.—The leaf is formed in such a way as to expose as great a surface as possible to the sun and atmosphere. Its structure is best seen from a transverse section under the microscope. Above and below is a layer of epidermal cells, enclosing air; next to them we have a number of cells rich in protoplasm, and containing green chlorophyll granules. The substance of the leaf is made up of spongy parenchymatous cells, with air-spaces between them. The lower surface is pierced by a number of small openings, called stomata, through which the gases and watery vapour can pass. The leaf-stalk divides up into a large number of sub-divisions, which run to every part of the leaf. These are the *veins*, and are made up of fibres and small vessels which convey the crude sap to the leaf-cells.

The **Functions** of the leaf are—

1. Assimilation.
2. Respiration.
3. Transpiration.
4. To store up nourishment.

Nourishment may be stored up in the leaf-stalk, as in the rhubarb; in the bases of the leaf-stalk, as in the onion and hyacinth; or in the leaf-substance itself, as in the aloe and agave.

The Reproductive Organs.—The ultimate object of a plant's existence is the propagation of its own species, and it is to this end that most plants store up such large amounts of food material in their roots, stems, seeds, etc.

Plants which perform the whole cycle of germination, growth, reproduction, and death in one year are termed *annuals;* if two years are taken, they are *biennials;* but if more than this period is required, they are usually known as *perennials.* Examples: (1) barley, (2) turnip, (3) many grasses.

Reproduction may take place asexually or sexually.

Asexually plants are reproduced (1) by cuttings, as a geranium cutting; (2) by grafts, as with the apple-tree; (3) by tubers, as of the potato; (4) by root-stocks, as the horse-radish, (5) by tuberous roots, as the Jerusalem artichoke; (6) by bulbs (axillary buds), as the hyacinth; (7) by runners, as the strawberry.

In all these cases the variety is preserved. The sexual mode of reproduction is the method chiefly relied on by the higher plants for preserving the species, and for the production of fresh varieties which may be better suited to any change of climate or circumstances that may have taken place, and thus enables them to survive in the struggle for existence.

A typical flower consists of at least four parts. These are, in order from the outside, (1) the calyx, (2) the corolla, (3) the andræcium, (4) the gynæcium. The corolla, when present, usually consists of green leaves, or sepals, sometimes scarcely noticeable. Their prime function is protection. The corolla is made up of the coloured petals, the most showy part of the flower. It serves to attract insects. The andræcium is the collective name for the numbers of stamens, or male organs. The gynæcium is the female part of the plant, and is made up of a number of carpels, each of which contains one or more ovules, or eggs.

Fertilization consists in the union of the contents of pollen grains (small bodies given off by the stamens) with the egg-cell contained in the ovary. In comparatively few plants does the pollen fertilize the ovules on the same flower, and consequently some means must be found for conveying it from one plant to another. There are two chief methods: (1) by the agency of the wind (anemophilous flowers), as in grasses and cereals; and (2) by the influence of insects (entomophilous flowers). In any case the pollen grain attaches itself to the stigma, the summit of the lengthened apex of the carpel. A long tube grows out

from it, and passes through the tissues of the style, until it reaches the ovary, or lowest part of the carpel. The contents of the pollen-tube become incorporated with the protoplasm of the egg-cell within the ovule. The result of this fertilization is, that the egg-cell begins to grow, and becomes the young embryo plant, while the ovule is changed into a seed.

[For a fuller description of fertilization, the reader should consult some work on Botany.]

B.—*Farm Crops.*

Agricultural Classification of Crops.

For agricultural purposes the main crops may conveniently be classified thus :—

1. *Root crops:* white turnip, yellow turnip, swede, mangel, carrot, parsnip.
2. *Tuber crops:* potato.
3. *Cabbage crops for forage:* kohl-rabi, kale, close-headed cabbage, or drumhead.
4. *Mixed clover and grass crops, or shortly grass for forage, hay, and pasture.* The chief clovers are trefoil, red, alsyke, and white. The chief grasses are Italian rye-grass, perennial rye-grass, Timothy, and cocksfoot.
5. *Cereal grain crops:* barley, oat, wheat.
6. *Leguminous seed crops:* bean, pea.
7. *Miscellaneous fodder crops:* white mustard, winter rye, barley, oats, etc.

1. Root Crops.

Duration.—Any plant with a vegetative organ specialized for purposes of storage must be of more than annual duration. Thus root-crop plants with storing roots are all biennials, and have two very sharply marked periods of growth :—

1. The vegetative period, or period of storage—first year.
2. The reproductive period, or period of seed-making—second year. Complete exhaustion of the plant is the consequence of seed-making.

The part used as crop is the root, the product of the vegetative activity of the first year's growth. Crop maturity or perfection is accordingly reached when the vegetative processes are completed, before softening and preparation for reproductive activity begins.

The time taken to arrive at this crop perfection by the various members of the group is the period of vegetation. The order is :—

Rapid Growers	White turnip—shortest period of vegetation, eight weeks or more. Yellow turnip—about four months. Swede—five months or more.
Slow Growers	Mangel—about six months, or longer. Carrot—six months or more. Parsnip—longest period.

This period determines the order of sowing, thus :—

White turnip—last sown.

Yellow turnip—a fortnight or a month earlier.

Swede—a fortnight earlier than yellow.

Mangel Carrot Parsnip	First sown in spring.

A short period of vegetation fits a plant for minor or "catch crop," and, in the root group, white turnip is most suitable for this purpose.

A long period of vegetation means more light and heat utilized, more assimilation, and consequent extra production of organic substances—in short, high nutritive value. Thus white turnips are least nutritive; carrots and parsnips most so. If seed, soil, and climatic peculiarities, or management shorten the period of vegetation, crop value is correspondingly diminished. Under such circumstances, the plant has not sufficient time to fully utilize the substances already extracted from the soil for production of nutritive organic material.

Root Distribution.—There is always a primary or tap root, the storing organ of the plant, and, accordingly, the special object of the cultivation. The absorbing roots are branched fibres, springing especially from the thin lower end of the tap, and spreading more or less horizontally in the ground. The two kinds of roots are—

1. The storing tap.
2. The absorbing fibres.

These fibres are variously arranged on the tap :—

1. In two longitudinal rows along the tap.
2. In rings around the tap.

The two-rowed arrangement is quite characteristic of Cruciferous roots (turnip and swede) and mangels; the ringed arrangement equally so of Umbelliferæ (carrot and parsnip).

A prolonged period of vegetation means deeper root. Thus, turnips are shallower than swedes, swedes than mangels, carrots than parsnips. Period of vegetation, root-depth, and drought-resisting power increase or decrease together. Drought-resisting power is a special feature of the deepest forms which affect light

soils, such as carrots. Underground water stores are at the command of the deep roots. The deep character of the root system necessitates deep cultivation. In rotation, such plants are rightly alternated with shallow forms, and root crops are accordingly interpolated between cereals with shallow roots.

Habits.—*Absorptive Activity.*—The chief supply of soil materials is wanted when most substance is being laid down in the body of the root, during the late months of vegetative life. In this respect roots differ quite from grain-producers, which use the soil at a more unpropitious season, during early year. If waste of manure is to be avoided, this difference must be carefully borne in mind.

The absorbing roots are dainty in their ways, inasmuch as they make, and can make, no use of insoluble minerals. The fact that insoluble substances, such as bone-meal, are, in certain circumstances, beneficial is no disproof. This peculiarity necessitates the artificial addition to the soil of readily available compounds, or fertilizers, as such compounds are termed. Roots, cabbages, and potatoes demand them most. A well-cultivated and well-dunged soil in a warm climate requires artificials least of all, for, in this case, the soil itself becomes a manure factory in which all the fertilizers are produced. Dung must therefore be lavishly applied, to meet the wants of crops demanding soluble substances; indeed, most of the farm dung is used for roots, especially on lands of lighter texture, where other dung-requiring crops are little grown.

Growth.—A plant grows in two leading directions: the root downwards, the stem upwards. Root crops devote their energies to downward growth at first, to establish themselves deeply in the ground. Not so the early weeds; these rush away the air parts, overtop and overshadow the crop, thus tending to choke it out. Clean land is therefore the essential for root production; from start to finish cleanness is the unconditional necessity.

Tap Root.—The tap root has acquired, by cultivation, the rank character marked by scant fibres, abundant water, immature products of nitrogen, and so forth. The carbohydrates take the form of sugar, which is so plentiful that roots are rightly called "sugar crops." The length of the period of vegetation naturally determines the percentage, thus:—

White turnip—least sugar
Yellow turnip.
Swede.
Mangel.
Carrot.
Parsnip—most sugar.

The percentage of dry matter follows the same order, thus :—

White turnip	8	per cent.	dry matter.
Yellow turnip	9	,,	,,
Swede	11	,,	,,
Mangel	12½	,,	,,
Carrot	15	,,	,,

The percentage of nitrogen follows the same law in members of the same family, thus :—

White turnip	0·16	per cent.	nitrogen.
Yellow turnip	0·20	,,	,,
Swede	0·24	,,	,,

Mangel and carrot, though containing more sugar, produce it at less expenditure of nitrogen, for the percentage of this latter substance stands midway between that of yellow turnip and swede.

Leaves.—The leaves are arranged as a rosette on an extremely short stem part, called "the crown of the root," although a true stem. This arrangement reduces the distance between place of production (leaf) and place of storage (root) to a minimum; most rapid communication is thus secured. The swede leaf has retained the waxy skin of its wild ancestor, a standing witness of hardy character and slow growth, as compared with cruciferous allies. As the wax disappears from the surface, the plant becomes less hardy, vegetates more rapidly, and, to accomplish this, produces more leaf at the expense of the root. The order for leaf surface is—

White turnip—most leaf, 20 per cent. by weight.
Yellow turnip—
Swede—least leaf, 14 per cent. by weight.

Dominant Manurial Ingredients.—Roots of most rapid growth require no special stimulus to vegetation, and, if light and heat supplies are sufficient, no extra stimulus to sugar formation. What such rank productions do require is more albumin and protoplasm to increase constitutional vigour and the working power of the whole machinery without disturbing the balance between root and leaf. Phosphates favour the production of solid albumins and protoplasm, and are special manures for rapid-growing roots, the turnips and the swedes.

When vegetative growth progresses too slowly, nitrogenous applications stimulate to greater activity, and are the special fertilizers for the slow-growing mangels and carrots. On light soils, favourable to nitrification, and not suffering from poverty—a rare occurrence—nitrogenous manures are scarcely necessary, even for slow growers.

In the colder climate of Northern Britain, the vegetative activity of rapid growers proceeds at much slower rate than in the south. Thus it happens that in the north mixed nitrogenous and phosphatic fertilizers are more in favour for turnips.

The ancestry of the crop also seems to affect the nature of the manure. Mangel, for example, is a direct descendant from the wild sea-beet, *Beta maritima*, and, like its forefather, requires much common salt. Taken as a whole, rapid roots are "phosphate-demanding crops," and slow roots "nitrogen-demanding.

Requirements.—*Soil.*—Soils of light texture, especially if somewhat calcareous and favourable to nitrification, suit all root crops, particularly those of rapid vegetation, as turnips. Deep-rooted carrots also affect light land; and peaty character is no drawback, since the plant uses comparatively little nitrogenous matter. Slow growers, like swede and mangel, preponderate on the heavier soils. In whatever soil, abundant water and fresh air are very necessary for the full crop of rank and succulent root.

Character in Relation to Soil.—In relation to soil, roots are (1) ameliorative, (2) cleaning. The crop is consumed on the farm, and, on light land, usually on the very field of production. What the animals retain is chiefly sugar, made from carbon dioxide and water, at no expense to the land. The excreta of the stock restore a very large proportion of the manurial constituents, more especially of nitrogenous compounds. Anything retained in the animal body is more than made good by the extra cake and purchased feeding-stuffs given with the roots. A crop like this, which utilizes soluble matter only, cannot and does not enable the cultivator to realize the innate riches of the soil. This is the special feature of amelioration by leguminous plants and grasses.

Successful growth necessitates soil specially fit for root life, since the produce is root; and he who crops land at profit must at some time or other bring the soil into this fit condition. Suitability for root life is attained, and attained best, in a rotation when the root crop is taken in hand. Then land is cleaned, tilled, and dunged, brought to a high state of fertility, and made most comfortable for root life in general. Any crop which accomplishes this, which specially ameliorates and specially cleans, is called fallow crop. Root crop, however, is not a complete renovation; its action must be supplemented by grass and clover production.

Chemical Composition.—Chemical composition depends, and must depend largely, upon the period of vegetation. Percentage of dry substance, organic matter, sugar, fat, all increase with the period of vegetation. The percentage of nitrogen, too, increases

as the period of vegetation lengthens in members of the same family, and accordingly the albuminoid ratio diminishes; thus:—

	Albuminoid ratio.
White turnip	1 : 6
Yellow turnip	1 : 7
Swede	1 : 8·3

Scantiness of fibre is intimately connected with the presence of amides and unsaturated nitrogenous compounds.

Manurial value increases with the period of vegetation:—

Turnip	4*s.* 0*d.*	per 1 ton of roots.	
Swede	4*s.* 3*d.*	,,	,,
Mangel	5*s.* 0*d.*	,,	,,
Parsnip	5*s.* 3*d.*	,,	,,

The carrot is peculiar, and is valued at the same rate as turnip; this means that it produces most organic substance at minimum expense to the soil.

Nitrogen, phosphoric acid, and potash are, however, often erratic in amount: the percentage depends on manure, on soil, and on climate.

The dry matter contained in roots is heavier than water, hence high specific gravity is a rough index of the solidity and value of the root.

Period of Highest Nutritive Value.—The crop makes no addition to its substances after vegetative processes have ceased; as marked by change of leaf colour from green to yellow. There is now preparation for reproductive activity—conversion of crude material into nutritive products, and softening of the cell walls to allow ready exit. During the warm months of late year most addition is made, and on the temperature which prevails at this season crop value greatly depends. A touch of frost may intervene and stop the vegetative processes in a single night. Rapidity of growth or period of vegetation has most to do with frost action. The law is this—the slower the growth the less effective is frost in checking vegetation, and bringing on premature ripening. The order is:—

White turnip, most readily affected by frost.
Yellow turnip.
Swede.
Carrot and parsnip, least readily affected by frost.

When the thoroughly ripe and soft condition is suddenly reached by the crop, it cannot be fed off in time to prevent almost total loss due to fermentation and putrefaction, set agoing by fungoid organisms. Because of this, rapid-growing roots must be taken in immature condition, not allowed to ripen, and quickly

fed off so as to secure least loss. Succulent products cannot, from their very succulence, keep sound for any length of time; the most watery must be fed off first. In general, the order in which they are consumed corresponds with period of vegetation :—

White turnip, used first in autumn.
Yellow turnip.
Swede, used in winter.
Mangel.
Carrot, used last in spring.

Mode of using depends on the Nature of Land.—On light land, root crop is fed off on the field of production. On heavy land this cannot always be done, because of the injury which results to soil from tread of animals. The policy is thus to allow an extra year or two in grass crop, and browse it at a season when no such physical injury results. The depasturing of heavy land is thus equivalent to feeding roots on light land. To be preserved over winter, roots must be protected from frost and fungi. To keep down fungi, thorough ventilation and prevention of heating are necessary.

Chemical Changes during Ripening.—During the period of vegetation the most important chemical change is production of sugar from carbon dioxide and water, under the influence of sunlight and heat. The carbohydrates show remarkably little tendency to saturate the nitrogenous compounds; instead of constructing nutritive albumins, crude albumins (amides) worthless for nutrition are formed. Supplies of phosphatic and lime compounds favour albumin and protoplasm formation. The proportion of fat is extremely small, ranging from 0·1 per cent. in rapid growers to 0·3 per cent. in the slow forms. During after-ripening the cell walls change their nature, and become more soluble and more permeable from diastase formation and action. Amides may also be converted into albumins. A similar wall-change occurs in germinating seeds, sprouting potato tubers, and so forth.

Principles of Cultivation.—Cultivation requirements are easily determined if the objects of root-growing are steadily kept in view. These objects, so far as the soil is concerned, are—

1. Physical and biological improvement.
2. Addition of readily available materials.

Root crops are thus much more than root producers. Above everything, they are soil improvers or fallow crops, since fallowing is merely another name for physical and biological improvement of the soil resulting from tillage and from dung. Physical improvement of soil means increased fineness of particles, and consequent intimate connection between root and soil. To the plant more intimate connection with the soil means more food-

making material and more comfort; such soil, even though poor, may yield as if rich. Exposure of as large a surface as possible to winter frost by autumn cultivation tends much to realization of this valuable accomplishment by land. Improved biological condition means—

1. Cleanness, freedom from injurious weed, seed, and insect.
2. Increased supply of pure air and water.
3. Active germ and root life.

Cleanness is attained by taking the weeds at their weakest, when "drawn up" and most superficial in position—that is, on the stubble, in autumn, immediately after removal of a cereal, when they are half starved and choked under the growth of the tall overshadowing crop. Autumn tillage, too, exposes injurious seeds and insects to winter cold and starving birds,—evidently most favourable conditions for destruction of such pests.

Few realize that an application of farmyard manure secures abundance of air, water, and heat in the soil. What is wanted is interstices full of pure air, not capillary pipes plugged up with poisonous water. The simple fact that land for crops is drained, either naturally or artificially, to suck the water out of interstices, amply proves that soil pores must function as air-pipes—not as water-pipes. Nevertheless, abundant water supply is quite essential, and, if not clogging the pores, must be within the soil particles like water within particles of swollen glue. Farmyard dung acts in this way, imbibes freely, and retains water. Like the drain, it keeps the air-pores free and open. At the same time the organic matter in the dung constitutes the principal food of soil germs, and in the soil plays very much the part of sugar in the brewers' vat. The products of the germ action on the mixed dung and soil are in their turn partly the active materials absorbed by plants for food-production, and partly poisonous gases like carbon dioxide, which must escape by open pores downwards into the drains, or upwards by diffusion into the air; if not, the roots cannot remain healthy and vigorous. Taken as a whole, autumn cultivation and farmyard manure, working in combination, make the soil a clean and comfortable habitation, ventilated by air-pipes, warmed by germ activity, supplied by imbibed water, and rich in food suitable for dainty and luxurious plants.

Spring cultivation aims also at the production of the seed-bed, which must be—

1. Moist for seed germination.
2. Fine, to prevent shading of the seedlings by clods.
3. Clean, to prevent choking of the seedling by weeds.
4. Rich, to hurry the tardy growth past early dangers.
5. Deep, to form a suitable habitation for a tap root.

After-cultivation includes thinning, hand-hoeing, horse-hoeing, and so forth. The other crops which permit of cleaning and cultivation during growth are potatoes, cabbages, and beans. To allow these operations to go on, and to secure free access of light on all sides, the plants are drilled in rows about twenty-seven inches apart. Hoeing of the ridged surfaces above the bed occupied by absorbing roots and dung, accomplishes much more than weed removal. The main object is to bring the unoccupied surface to a state of maximum germ activity—to use it as a nitre bed. What bare fallow accomplishes, can thus be done better under root crop. The hoe opens the pores, allows free passage of air and water, places the soil germs in the best feeding-ground, and nitrification is most favoured. When a shower of rain comes, the manufactured fertilizers are washed out of the surface into the absorbing-area beneath, and held there imbibed by dung ready for utilization by the roots. This "nitrate catching" is the great advantage which the cropped fallow has over the bare fallow. It is not, then, so much the rain which benefits the crop, but the fertilizers washed by it into right position. It may accordingly be taken as a general rule that soluble nitrogenous fertilizers are uselessly applied to any crop which is thoroughly cultivated during growth, and over which an effective nitre bed, sufficient for the wants of the crop, can be formed. When such is not the case, nitrogenous fertilizers are always useful, except for leguminous plants. Hoeing, too, prevents escape of water from the root-bed during time of drought, chiefly because of diminished evaporative surface.

Capillary pipes full of water have no existence in a soil fit for root life, and certainly none in a dry surface. Any explanation of the action of hoe and harrow which deals with pipes full of water, has, and can have, no foundation in fact. *Hoeing, then, is equivalent to watering the plants during a period of drought,* and, when rain comes, an application of nitrogenous and other fertilizers. In the warm climate of England surface nitrification may go on with sufficient rapidity without the special stimulus of ridge or hoe. There, turnips and rapid roots are grown on the flat, and less worked by the hoe than is the case in Scotland.

In thinning, distance left between the plants depends upon the period of vegetation, since this has most influence upon the size ultimately attained. The following distances are usually given :—

White turnip		11	inches	between	the	plants.
Yellow	,,	12	,,	,,	,,	,,
Swede	,,	13	,,	,,	,,	,,
Mangel	,,	14	,,	,,	,,	,,

Taken as a whole, root cultivation is the most complicated and the most expensive. Therein are involved—

1. Preparatory cleaning.
2. Dunging and fertilizing.
3. Cleaning and cultivating during growth.

Influence of Climate on Perfection of Growth.—Moist atmosphere, in general, favours vegetative growth, and roots are no exception. Dry climates are suitable only for the slow-growing, deep-rooted and drought-resisting members of the group, the mangel and the carrot. Heat requirements increase with period of vegetation, thus:—

White turnip Yellow turnip Swede	requiring least heat.
Mangel Carrot Parsnip	requiring most heat.

Rapid growers, requiring least heat, naturally reach greatest perfection and yield largest crops when grown in the cooler North. Thus "fifty tons of turnips are as readily produced on an acre in Scotland as twenty tons in the South of England." Slow growers, requiring most heat, flourish in Southern Britain, and in the North large crops can only be raised with exceeding difficulty and in the warmest seasons.

The order is:—

White turnip Yellow turnip Swede	most perfect in the North.
Mangel Carrot Parsnip	most perfect in the South.

Alternation of rain and drought must give the largest crop of nitrogen-demanding roots, like mangel, because of the excessive nitrification under such climatic conditions.

Systems of Husbandry.—*Light Land.*—On light land root crops may occupy one-fourth of the whole arable area, as in the typical Norfolk rotation:—roots, barley, clover, wheat. As the climate becomes moister and more suitable for grass, roots are diminished to one-fifth, one-sixth, or one-seventh.

Heavy Land.—On heavy land, in climates suitable for grain-growing, roots are reduced to one-sixth, and the bean is introduced thus:—Roots, spring cereal, grass, winter cereal, beans, winter cereal. As the climate becomes moister, grass is specially

favoured, and the proportion of roots is now diminished to one-seventh or one-eighth.

Rapid-growing Roots.—If from any cause root growth proceeds too rapidly, the proportion of organic matter and feeding power diminish. This is a frequent case with turnip and swede grown in warmer parts of England. The stimulants of extra rapidity, extra production of stem and leaf, are nitrogenous compounds, heat, and moisture. Now the special object in growing root-crop is root produce, not stem and leaf, hence nitrogenous fertilizers must be used with caution, not only to retain root and leaf at proper balance, but also to secure a period of vegetation sufficiently long for nutritive value.

Slow-growing Roots.—If the climate be rather slow, then certainly nitrogenous compounds are beneficial. Potash too has beneficial action, especially when supplies of light and heat are insufficient, as in a cold wet season.

Rotation.—Cereals and grass can utilize all the resources of the cleanest and most fertile land; these, then, most fitly follow fallow crop in the rotation. The cereal yields its grain while the grass is getting ready, and that is why the two crops occupy the land together during the year succeeding the fallow. The kind of cereal used depends upon when the land can be got ready for sowing.

2. Tuber Crops.

Duration.—Potatoes are perennial plants, immediately recognized as such by the presence of storing organs of vegetation, namely, the stem tubers. According to period required for ripening the tubers, the varieties are designated as early, requiring about sixteen weeks; medium; or late, requiring twenty-four weeks. Time of setting depends upon temperature, since the young plants may be destroyed by a touch of frost.

Root Distribution.—Neither the tubers nor branches which bear them are roots. The true and only roots are fibres produced in tufts by the underground portion of main stem and of its tuber-bearing branches. These true roots spring from the nodes, and branch little as they go through the ground.

If the potato plant has been grown from true seed, formed in the fruit or "plum," there is an additional root system composed of a tap with absorbing fibres.

Many suppose that potato planted at an excessive depth produces increased amount of tuber. This is a very erroneous idea; loss results from extra deep setting—loss of time; and extra depth is merely equivalent to extra late setting.

The character of the underground stems which bear the tubers varies thus :—

1. Short.
2. Medium.
3. Long.
4. Branched or simple.

The tubers vary thus :—

1. Size—small, medium, large.
2. Form—round, elongated or kidney, egg-shaped; the transverse section is either circular or elliptical.
3. Setting of the eyes—deep, medium, superficial, prominent.
4. Colour of skin and flesh—white, yellow, red, blue.
5. Skin surface—smooth, rough, netted.
6. Contents—wet, dry, waxy.

Habits.—*Absorbing Activity.*—Like root crops, potatoes require soil materials in soluble condition and ready to hand; like roots, too, they are quite luxurious feeders, and very much dung may be lavished on them.

Tubers.—Rankness and succulence are characteristic of the tubers. In succulence they are far behind roots—containing, as they do, one-fourth of their weight of dry substance, whereas the most solid roots, such as mangels, contain less than one-eighth. The carbohydrates take the form of starch, and these are accordingly called "starch-crops." Yield is as variable as period of vegetation.

Air Parts.—Air parts vary in habit of growth—compact or loose, erect or spreading, tall or short.

The stem is slender or robust; the leaf-colour light or dark green; the leaf-surface rough or smooth.

The flowers are white, light purple, reddish purple, or purple.

Multiplication.—The crop may be produced in various ways :—

1. From sets.
2. From whole tubers.
3. From true seeds formed in the fruit or "plum."

Potato sets are cut portions of tubers planted for purposes of propagation. Certain peculiarities of the tubers must be taken into account, in order to cut the best sets. The buds at the apical end of the tuber (the rose) grow more vigorously than those of the base (the heel); as is to be expected, the apical buds are specially prepared by the plant to form the leading shoots. In making sets, therefore, the base of the tuber may be cut off and cast aside. The tubers, too, contain a ring of vascular bundles running longitudinally from the heel, and bending out to supply the eyes—a fact rarely, if ever, taken into account in preparing "sets." The apical end must be cut *longitudinally* to

preserve the vascular bundles intact. One or two of the most vigorous buds ("eyes") should be left on each set.

Cuts from large mealy tubers favour the production of a large crop of mealy tubers.

True seeds are only sown for the purpose of obtaining new varieties which withstand the attacks of fungoid disease.

Sets and whole tubers may be sprouted in :—

1. Soil in field.

2. Boxes in house.

The latter course is adopted for safety and rapidity where circumstances and early market demand it.

Requirements and Dominant Manurial Ingredients.—The extensive underground growth and development of this crop marks it out as requiring a specially free supply of soil, air, moisture, and heat. Soil of light texture, loaded with a moisture-holding and heating apparatus—dung, meets these physical requirements best. Warm soil not only favours the underground growth, but the extensive chemical changes which go on in the tubers when starch is manufactured therein. The potato plant makes starch in two ways :—

1. From carbon dioxide and water in the green parts exposed to light.

2. From sugar in the underground tubers.

Potash compounds are always required in connection with starch formation, and in the potato not only is starch production excessive, but it has to go on at two centres—in leaf and tuber; double supply of potash accordingly is requisite. Potato is thus a "potash-demanding crop," and more especially so because it is usually grown on light land poor in this ingredient. However much potash may be in the soil, that which is soluble can alone be used.

Character in Relation to Soil.—The potato crop is :—

1. Exhausting.

2. Cleaning.

This is not a true fallow crop—the tubers are sold off the farm. An average crop of six tons of tubers carries away :—

Nitrogen	.. ..	47 lbs.
Phosphoric acid	..	$21\frac{1}{2}$,,
Potash	.. ..	$76\frac{1}{2}$,,

The potato is cultivated on the same principle as roots, and, like roots, is a cleaning crop, usually preceded and followed by a fouling cereal. Unlike roots, it is not restorative, and there fore, as stated above, it is not a true fallow crop.

Chemical Composition of Tubers.—This crop is less succulent

than roots, and contains twice as much dry matter, albuminoids, carbohydrates, and fat as mangel although the ash is practically the same in amount.

Chemical Changes in Ripening.—The chief difference between the ripening of this and root crop is the production of starch instead of sugar in the storing tubers. This tuber starch is, of course, made from sugar material supplied from the leaves. Formation of starch granules is the special business of the starch builders in the cells of the tubers. Potash and lime compounds together aid the work; without the lime compound, dry quality can scarcely be secured.

Period of Highest Nutritive Value.—The crop ceases to draw from soil and air when the leaf begins to change colour, and is ready for lifting when the shaws have emptied into the tubers. The corky skin of the tuber should be firm, and not rub off with the fingers; firm skin is quite essential if the potatoes are to be kept in store.

Principles of Cultivation.—Potato is cultivated on the same principles as roots:—cleaned, dunged, and fertilized, also cultivated during growth. Instead of sowing seed, sets are planted and the crop has to be dug up—very difficult, if not impossible, on wet heavy clay land. The crop cannot be set till all chance of a "nip" from frost has passed. In spite of this, special earliness may be secured by "sprouting," or "greening," in boxes, before planting.

In selecting sorts for setting, the following points of pedigree must be attended to:—

1. Early maturity.
2. Proportion of tuber product.
3. Liability to disease: least in new varieties.

The tubers should be—

1. Of medium size.
2. Well formed.
3. With superficial eyes.
4. White coloured.
5. Rough skinned.
6. With dry and mealy, well-flavoured contents.

Care must be taken during growth to keep the tubers well-covered with earth, for if light has access the contents of the potato form green chlorophyll.

Influence of Climate on Perfection of Growth.—Perfection cannot be reached in wet climate and season, because wet runs the plant into shaw, and disease ravages the crop. By growing early varieties disease may be avoided to a great extent.

Influence of Soil.—If the soil be persistently wet, so that air

cannot enter and circulate, or if excessive nitrogenous food be supplied, a small crop of watery tubers and a large proportion of air parts or "shaws" is the result. Wetness and heavy soil, excessive nitrogenous food and shade, alike favour the air parts at the expense of underground tubers. Phosphates, potash and lime compounds are very essential for production of dry tubers and for checking excessive "shaw" production.

Systems of Husbandry.—In a system of husbandry, the potato is best preceded by an ameliorative crop of grass, and followed by an exhaustive fouling cereal which uses the clean land and excess of manure left in the ground or added to it for the special use of the cereal; thus:—

Roots, cereal, grass, grass, potato, cereal,

as in the East Lothian six-course rotation.

3. Cabbage Crops.

Duration.—The cabbage plants are biennials, and the object of cultivation is a strong vegetative organ—not root, however, but stem as in kohl-rabi, or leaf as in cabbage proper. The period of vegetation is less for kohl-rabi, more prolonged for cabbage.

Root Distribution.—The tap root is comparatively short and scarcely enters the subsoil. The absorbing roots are branched fibres with a horizontal spread, and arranged in two rows along the tap, as in all cruciferous plants.

Habits.—*Absorptive Activity.*—Like roots and tubers, they use soluble food, and soluble food only; hence artificial fertilizing of the soil is advantageous. They are the most luxurious feeders of all, and accordingly require maximum quantity of dung.

Storing Organs.—Storage of organic compounds in an air part is a feature which distinguishes cabbage crops from roots and tubers. Place of production and of storage are one and the same, the leaf, in cabbage proper; whereas in kohl-rabi the manufactured compounds are transferred from the leaf into the stem.

Hardihood.—Like their wild ancestor (*Brassica oleracea*) the leaves have waxy skin. As with swede, so here, wax is a sign of hardihood, of slow and steady growth. The open-headed cabbage (kale) can remain out all winter, but the close-headed (drumhead), from the peculiar leaf arrangement impressed upon it by cultivation, is liable to injury both from frost and rain. Kohl-rabi is the least hardy member of the group.

Growth Forms.—The growth habit of the air parts varies thus:—

1. The leaves are spread and not closely overlapped to form a head—kale.

2. The leaves are close-packed, erect, concave, and fit into one another to form a head—cabbage, or drumhead.

3. The leaves are open, but the stem which bears them is specially thickened for purposes of storage—kohl-rabi. In this case the air stem assumes the form taken by the root of the turnip and its allies.

Dominant Manurial Ingredient.—Luxuriant growth of aërial vegetation—stem and leaf—is always favoured by nitrogenous compounds, and by moisture alternated with drought; nitrogenous fertilizers are thus specifics for cabbage crops which are wanted to run to stem and leaf. Grown as they are on heavy land, where nitrification is not favoured, nitrogenous fertilizers become essential, and especially so in wet seasons. The plants revel in such food; indeed, cabbages become poisonous if the nitrogenous applications are too lavish. In ordinary field cultivation, this can, however, scarcely occur. Like slow roots, cabbages are "nitrogen-demanding crops."

Requirements.—To produce a large leaf surface requires a soil specially rich in water, since evaporation increases with the size of leaf, and heavy soil is accordingly most suitable. As evaporative surface diminishes, lighter soils can be used as for kohl-rabi. This latter form yields largest crops on the black peaty soils of the fens, which do not suit root produce. Warmth of soil is less requisite than for roots, because the produce of cabbage crops is aërial.

Character in Relation to Soil.—Like roots, these are fallow crops, and possess the two properties characteristic of such, namely—

1. Ameliorating character.
2. Cleaning character.

Consumption on the farm, and nothing else, constitutes the ameliorative, or restorative, character of these crops; they must always be cultivated so that the land is clean and kept clean around them.

Chemical Composition.—These are much like root crops in composition, and contain about ten per cent. of dry matter. Drumhead cabbage is composed thus:—

Water	89·42	per cent.
Albuminoids	1·50	,,
Fats	0·08	,,
Carbohydrates	7·01	,,
Fibres	1·14	,,
Ash	0·85	,,
Total	100·00	

Period of Highest Nutritive Value.—The plants are taken when well-grown. Like roots, cabbage products are succulent, cannot be kept, and are used green. They are principally grown for use in early autumn before turnips.

The chemical changes during ripening are of the same nature as in roots.

Influence of Climate in Perfection of Growth.—A temperate and moist climate brings these crops to highest perfection. The climate of Scotland is rather cold for kohl-rabi.

Systems of Husbandry.—On heavy soils, in moist climate, cabbages, being fallow crops, enter into rotation in place of roots. By their use, the clay-land farmer is enabled to secure longer time and more suitable season for thorough tillage and cleaning of his land, as well as much larger crops. Cabbages planted out in October are ready in June or July; and if planted out in June and July are ready in December or January.

4. Grass Crops, including Clovers.

Duration.—*Grasses.* Grass crops, after sowing, allow a season to pass over their heads before yielding the produce of stem and leaf—the "forage," as it is called if cut, "herbage," if depastured. Late yield is characteristic of plants more lasting than annuals. The seedlings only begin active vegetation towards the end of summer, and produce the main crop in the early part of the next year. Italian rye-grass is of shortest duration, producing for one or two years. The other grasses endure still longer, but lease of life depends in no small measure upon mode of cropping; if allowed to seed freely, the plants are more rapidly exhausted. This is because material for bud-making is diverted into the seeds; the weakened buds which are left can yield but poor produce.

Clovers.—The order of duration of the clovers is—

Trefoil—least lasting, almost biennial.
Red clover—biennial.
Alsike clover—triennial.
White clover —most lasting, perennial.

Root Distribution.—*Grasses.*—Each shoot of grass is provided with its own tuft of fibre roots, which branch extensively in the surface soil. Length, depth, and amount vary very much, and depend upon size and amount of leaf; the depth more especially depends upon the height to which the plant is allowed to grow and the time of flowering. Large and abundant leafage means long and abundant roots; tallness and late flowering, root

depth—for example, timothy. In general, the bottom and depastured grasses are shallow rooters, while the top species, especially if allowed to grow tall, become more deeply set.

Clovers.—Each clover plant has a single primary or tap root, which grows vertically into the ground, and, as it descends, produces successively deeper sets of lateral root fibres. These fibres spread outwards from the tap, branch freely and produce the nodules or tubercles so characteristic of all leguminous plants. Food supplied to the leafy branches must pass to them through the tap, and through the tap alone; in this respect the clovers are very different from the grasses. The root habit of white clover is different. The stem creeps along the surface of the ground, and, as it advances, short root fibres spring from it, and enter the surface soil, from which the mineral matter passes through the root fibre directly into the stem.

Order of root depth is—

White clover—shallowest roots.
Trefoil.
Alsike clover.
Red clover—deepest roots, often entering the subsoil.

White clover, from its shallow-rooted character, is most influenced by drought. Depastured, the clovers, too, are naturally more shallow-rooted than when allowed to make height growth.

Habits.—*Absorptive Activity of Grasses.*—Grass roots are voracious feeders on the insoluble minerals of the soil. Nitrogenous food must, however, be provided in soluble form: if excess of nitrogen is at command, they overfeed and become rank; the herbage is then unfit for animal food. When nitrogenous compounds are defective, the plants become fibrous, less nutritive, and highly silicated.

Absorptive Activity of Clovers.—Like grasses, clovers prey extensively upon insoluble minerals, but, unlike them, prevent entrance of useless silica. Unlike them, too, clovers obtain nitrogenous matter from the germ occupants of their tubercles, which in turn utilize the free nitrogen in the soil atmosphere. Under the influence of soluble nitrogenous compounds, these are not favoured like the grasses; and in mixed herbage with abundant nitrogenous manure the grasses suppress the clovers. Of all the components of grass crops, red clover is the most dainty feeder; it is specially particular as regards soil diet, and makes free use of soluble materials.

Towards the end of summer, the seedlings begin to feed vigorously, to grow, and branch extensively; the least lasting (trefoil and rye-grass) beginning earliest. Accordingly, any dung for the

especial benefit of the grass crop must be put in so as to be ready for use at this time. From their special mode of feeding, mixed grasses and clovers alike enable the cultivator to realize the innate wealth of his land.

Grass Growth.—The seedling grass forms a set of buds immediately below the surface of the ground. These remain dormant until the end of summer, when they become active, and each develops into a leafy branch with a feeding apparatus—a set of root fibres springing from its base. In immature condition these branches pass the winter; in spring, growth begins anew, and in summer, maturity is reached. Like the seedling, each of these branches produces a set of buds which pass through the same phases of development as the parent. New broods of branches are thus coming forward for next crop, while their parents are cut down for hay or depastured by browsing animals. The peculiarity here is that the progeny never catch up with the parents, and always remain a season behind. Annual grasses, like cereals, accomplish the whole development in a single season, parents and progeny coming into ear practically together. When bud-making ceases, there is nothing left to continue the growth, and the end of the plant is at hand. Among grasses, Italian rye-grass reaches this period most rapidly; for a year or two it branches and forms crops so vigorously that complete exhaustion results. Italian leads the short and merry life. Perennial, in spite of its name, often follows close upon it, and three or four years after sowing, mere remnants may alone be left. Those grasses which shoot most freely and produce crops of branches in most rapid succession, are evidently most valuable. Such are rye-grass and cocksfoot, which yield abundant crops and after-crops of branches within the year. After-crops of branches, when cut, are called after-math.

If the branches of the grass are compacted into a single close tuft, the plant has little hold upon the ground, and uprooting by frost or by browsing animals is most easy. If the arrangement is a loose one, and the branches more creepy underground, the hold is evidently much firmer. Loose branch arrangement, too, is essential, if ground is to be completely covered by grass, for bare spaces are inevitable between compact tufts. To get complete sward, loose and tufted growers should be mixed together.

Pasture Grasses.—Grasses, especially suited for pasture purposes, should produce abundant leafage close to the ground, and flat branches not liable to injury under the tread of animals. Both requirements are specially fulfilled by perennial rye-grass, cocksfoot, and poas.

Clover Growth.—During spring and summer of the year of

sowing, the produce of the clover is much too scant for crop; as yet each plant, except the almost annual trefoil, is represented merely by a single root and shoot. To yield full produce, many leafy branches and roots to feed them must develop. The buds which make the branches originate from the base of the primary shoot, and begin to develop as the summer draws to an end. The tap root can alone provide the feeders for the leafy branches; this it does by descending deeper, and forming fibre outgrowth from its depths. During winter, feeding stops, and the branches cease to grow. In early spring, however, development begins again; by summer the leafy branches reach the flowering stage, and crop is ready for taking. Still further crop is wanted; further branches and feeders must be produced. Each branch turns out a brood, and the tap root goes still deeper than before. If the depths now preyed upon are physically or chemically incompetent for root life, or yield too little food supply, further crop fails to come forward, and the farmer says the land is "clover-sick." Such "clover-sickness" is, of course, a result of bad physical or chemical condition.

Red clover is the most highly cultivated form, the deepest and most dainty feeder, hence land is most often "sick" of it. So long as the roots are in the comfortable and fertile surface soil, the clover thrives, but in the subsoil layers, the surroundings are often unpropitious.

Thickness or thinness of the preceding cereal crop has much to do with success or failure of clover. Spots of a field specially thick with cereals bear stunted clover; on the other hand, where corn has been thin, clover is specially luxuriant.

Alsike grows on the same principle as red clover, but avoids untimely end by diminishing the length growth of the tap, and confining its ravages chiefly to the surface soil, hence land is rarely alsike "sick." White clover grows quite otherwise; it runs its stem along the surface of the ground, producing feeding outgrowths as it goes. It is not at all dependent upon depth, but merely surface richness. This habit of growth, combined with perennial character, renders white clover the most valuable for pasture purposes. The very tread of animals acts favourably, and keeps the moisture in play in the surface at free disposal of the shallow roots. The best trodden portion of the field, indeed, produces most clover for this very reason. In the annual, or almost annual, species—trefoil—there is little time for descent of root, and the branching growth is all but finished within a single year.

Clover Leaves.—The blade of a clover leaf is composed of three distinct parts or leaflets. Leaf distinction is easy, thus :—

1. Leaflets hairy on upper and lower surfaces.
   (*a*) Red clover—leaflets large, the median sessile.
   (*b*) Trefoil—leaflets small, the median stalked.
2. Leaflets bald; at times hairy on lower surface only.
   (*a*) White clover—lower surface of leaflets glossy.
   (*b*) Alsike clover—lower surface of leaflets dull.

The internal peculiarity of the leaves of clovers and all leguminous plants is the oxalate of lime crystals in the cells. No such compounds are met with in grasses grown in Britain. For this reason, lime compounds must be abundant in order to produce the largest crop of clover; and the same applies to all leguminous crops.

Dominant Manurial Ingredients.—For grass crops so far as composed of grass, nitrogenous food is the dominant manurial ingredient, since the object is stem and leaf production. Without adequate supply, the grass become fibrous, and the yield is also less.

The clover portion of the crop is dominated chiefly by the potash supply, more so in cold climates; in warm climates, however, phosphates have much influence. Lime compounds are always necessary for clover production, chiefly to neutralize the oxalic acid, a poisonous by-product resulting from the vital activity of the plant. The mixed crop is accordingly "nitrogen- and potash-demanding."

Requirements.—The component plants of grass crops have been so little modified by the art of cultivation, that they retain the hardihood and contented nature of wild forms. Red clover, as already mentioned, is the most dainty, and least easy to be satisfied; rye-grasses and cocksfoot, the most contented. Grass crops, accordingly, can be taken on land of all texture, of all grades of richness and fertility. The rapid forms with shortest lease of life naturally prefer light quick land. Such are Italian ryegrass and trefoil. Soil of heavy texture suits perennial rye-grass, timothy, crested dogstail, meadow fescue, foxtail, rough-stalked meadow grass, and alsike clover. Cocksfoot suits all soils, and along with timothy does well on moorland, and this because of the extra abundant supply of feeding roots. Heavy clays with innate wealth of mineral compounds surpass all others in grass production, and are often laid under grass crop for many years.

Too much water cannot be present, provided that the soil pores are in free communication with fresh atmospheric air to a considerable depth. If not, however rich the soil, the roots remain in abeyance, and the shoots are starved to death, or linger on in the starving state; surface rooters alone survive; the rich meadow dwindles to a poor pasture, and even the pasturage is affected, for a mossy cover takes the place of grass. Any crop

residue is little the better for the removal of the mossy cover—the want is fresh air, in which the feeding fibres can breathe and grow and live.

Character in Relation to Soil.—Mixed grass crops are—

1. Ameliorative and dung the land with residual roots.
2. Additive of nitrogen.
3. Physical and biological soil improvers.

Ameliorative character is very pronounced, since the produce is used not only on the farm, but, when depastured, on the very field of production, like turnips fed off on light land. The grazing animals may be partly fed on purchased feeding stuffs, and thus higher fertility is reached, since the excreta add more manurial substance than is carried away in the animal body and its products. The great amelioration which results from the production of a large quantity of a dung thoroughly and properly distributed throughout the soil and composed of root residues is often overlooked. An instant's consideration shows that such residue must consist very largely of protoplasm, "the basis of life," and as a general manure surely such a mixture cannot be surpassed. No wonder the after-crop succeeds so well, for the root residue beats the most skilful mixture which the farmer can make.

The clovers leave the land, after the crop, richer in nitrogen than before, and this because they take elementary nitrogen from the soil atmosphere, and serve it up in forms most acceptable to other crops. The action is due to the nodules on the roots of all leguminous plants. These nodules are supposed to be caused by a fungus, and, when cut open, present a fleshy appearance. The fungus takes up elementary nitrogen for its own use, manufactures it into organic compounds, and then passes it on through the cell walls into the roots of the host. This action for the mutual good of the two is known as "symbiosis."

Physical and biological soil improvement is the necessary consequence of the additional organic matter left as roots distributed through the soil. By such addition, compactness without hardness is gained; fresh water is held, not in the pores, but imbibed in organic matter, leaving the pores open to fresh air; fertilizers also are kept in the soil, and not run off by drains. Clover cropped as hay, leaves more root residue than when depastured, since the plant has been allowed to make more leafage and proportionate roots to meet the demand for mineral food supply. Crops like grass and clover which are returned to the land, which convert insoluble minerals into available food, which purvey additional nitrogenous compounds, and which dung the land with root residue, must conduce to the very highest fertility,

and pave the way for dainty feeders demanding nitrogen, such as wheat and other cereal crops.

Taken as a whole, grass crop is the great "manure purveyor," providing not only extra nitrogen, but more potash and phosphoric acid in available forms. Under roots the land is nitrified; under grass and clover the minerals are made available, and additional nitrogen compounds manufactured. At one time the field is a nitre factory; at another potassic and phosphatic fertilizers are made. The work of the root crop is thus supplemented and completed by grass and clover; proper cultivation of roots and grass underlies all successful and profitable farming.

It is pure fancy to suppose that land under grass is "at rest." Certainly there is rest, so far as use of tillage implements upon it is concerned. But when in grass and clover, much more potent mechanisms than ploughs, hoes, and harrows are at work, and the very antipodes of rest, maximum activity, indeed prevails, not only at the surface, but in the very depths of the soil—a point of great importance in connection with deep tillage, and the labour bill.

Chemical Changes in Ripening.—Starch is the fundamental product from which all the organic substance in grass and clover is derived. It is produced from carbon dioxide and water at no expense to the soil other than a small percentage of potash ($1\frac{1}{2}$ per cent. in grass and clover hay). By its union with nitrogenous compounds amides are first formed, and from these, in turn, albuminoids. The albumins of clover may be produced from elementary nitrogen, but those of grasses only from nitrogenous compounds supplied by the soil itself. Soil phosphates (about one-half per cent. of hay) are also required in connection with albumin formation. In plants like grasses and clovers, so little modified by cultivation, amides tend to form albumins rather than to remain in unsaturated condition. This is a point of contrast with root crops, and intimately connected with increased tendency to fibre formation. When flowering and fertilization have taken place, the nutritive matter in stem and leaf streams into the developing seeds. After this change, the carbohydrate, left behind, readily becomes converted into fibre, as it is no longer kept in check by amides and such compounds. Not only is a large amount of fibre formed, but the nutritive materials left in the cells are much more firmly imprisoned than heretofore, so much so that the digestive juice of animals can extract extremely little. The same fibrous change may occur before flowering when the crop is thin, so that light has free access to the stems. The by-product, oxalic acid, forms abundantly in clovers,

apparently in connection with albumin production. Lime must accordingly be freely supplied to serve as an antidote to the poisonous acid, to convert it into harmless oxalate of lime.

Period of Highest Nutritive Value.—When the cell walls are the most permeable and the cell contents richest in digestible food material, grass crops are evidently at their highest nutritive value. The state of perfection is usually reached when the plant is coming into flower, and before the seeds begin to form. The hay crop is accordingly taken at flowering, which is about a month later in the north than in the south. The usual time of flowering for grasses is—

Perennial rye-grass,	first	week of	June.
Italian „	second	„	„
Cocksfoot	third	„	„
Timothy, ...	first	„	July.

The clovers flower in order of duration thus:—

Trefoil—earliest.
Red clover—with rye-grass.
Alsike and white—latest.

When cut after flowering, the product contains more fibre and less digestible nutriment. When taken before flowering, the crop is very digestible, and contains more amides and less fibre. High nutritive value is never reached by grass plants grown in unsuitable soil and poorly fed. Even young produce grown under such circumstances is fibrous and indigestible.

Chemical Composition.—The percentage of dry matter in the green herbage varies between 20 and 30 per cent.; in the hay between 84 and 86 per cent. Average hay is composed thus:—

	Clover Hay. Per cent.	Meadow Hay. Per cent.
Dry matter	84	86
Ash	7	6½
Nitrogen	2	1½

Of the ash, about 2 per cent. is lime in clover hay, and 2 per cent. silica in grass hay.

The organic matter of 100 lbs. of hay is composed thus:—

	Clover Hay. Per cent.	Meadow Hay. Per cent.
Albuminoids	12·5	9·5
Carbohydrates	36·0	41·5
Fats	2·5	2·5
Fibre	26·0	26·0
	77·0	79·5

The albuminoid ratio of hay is —

Alsike clover ..	1 : 1·9	Perennial rye-grass ..	1 : 3·8
Red clover	1 : 2·2	Cocksfoot	1 : 4·0
White clover	1 : 2·3	Italian rye-grass ..	1 : 4·7
Trefoil	1 : 2·4	Timothy	1 : 7·0

Taken generally, the albuminoid ratio is—

Clovers	1 : $2\frac{1}{2}$
Grasses	1 : $4\frac{1}{2}$
Roots	1 : $8\frac{1}{2}$

Principles of Cultivation.—*The Land.*—The object of grass and clover growing is to secure the largest possible yield of most nutritive product. The land *must* fulfil certain conditions, and be—

1. Suitable for the plants selected.
2. Perfectly clean.
3. Well and deeply tilled.
4. In the highest state of fertility.

These conditions are best satisfied after root crop—if possible fed off by sheep—the only fit place for grass in the whole rotation. The simple fact that the sown crop cannot produce till a year has passed over its head shows the necessity for perfect cleanness. If these conditions are not fulfilled, a large crop may certainly be got, but a crop of bad weeds, plants imperfectly nourished and full of fibre, indigestible, and almost worthless as food. Grass of highest nutritive value is not necessarily that first produced. On heavy land it may be so, but science and experience alike agree that this is not the case on light lands.

The Seed-bed.—The seed-bed *must* be very fine; if not, many of the seeds fall between clods, and lie too deep. From seeds in this predicament, the plant product is either weakly or killed.

The Seed.—The seed must be properly proportioned so as to accomplish the object in view. Putting seed into a balance and finding exact weight cannot, and does not, give any idea of how much of it can grow. What is wanted is a certain weight of *growing seed.* Actual experiment shows that the weight of *growing seed* capable of covering an acre is :—

	Lbs. of Growing Seed per Acre.		Lbs. of Growing Seed per Acre.
Perennial rye-grass ..	40	Timothy	15
Meadow fescue ..	37	Red clover	16
Italian rye-grass ..	33	Alsike	9
Cocksfoot	19	White	8

The seed is broadcasted by machine. The covering ought to be very slight, about a quarter, but not over half, an inch,

because the seeds do not grow well when more deeply covered. On heavy soils no covering is required—rolling suffices; on dry soils the seeds are scratched in by a light harrow and rolled. Rolling is usually necessary to keep the seeds uniformly moist during germination.

Protective Crop.—The ingredients of the grass mixture are not annuals, and accordingly do not develop crop during the year of sowing. Under such a crop the ground would be very bare and practically idle through a season of growth. To utilize the bare ground, to keep down weeds, and to protect the seedling grasses from cold, an annual crop which develops its branches within the season is sown. This protective crop must not occupy the ground too long, must overtop the grass seedlings to be a sufficient protection, and yet must allow sufficient light to reach the grass. A thinly sown cereal meets the case. If the protective cereal is too thick, or happens to lodge, the clovers are more seriously injured than the grasses. The grass mixture is either sown at the same time as the cereal, or after it has made some progress in growth. Taken as a whole, the cultivation is quite simple, since the work has been done for the root crop. A seed-bed is prepared, and the seed harrowed in; an application of the roller to the young growth finishes the business. The great difficulty is to have a thin cereal crop: the real danger a thick cereal crop.

Influence of Climate on Perfection of Growth.—Leaf and stem production are favoured by moist climate and by plenty of rain spread over many days. Under these conditions of climate grass grows to highest perfection—witness the moist and rainy coast of Western Britain. For hay-making, dryness is wanted when the crop reaches the flowering stage.

System of Husbandry.—Grass takes its place after a crop which ameliorates and cleans the land, leaving it in high fertility. The fit precursor is accordingly fallow or roots, and grass or clover with its protecting cereal always follows this crop. A year, however, elapses before the produce is taken; thus a cereal holds the land and serves as a "nitrate catcher" until the grass is ready to yield. Most stress is laid upon grass crop in moist climates and on heavy lands rich in insoluble minerals—the fitting prey of grass and clover roots. Under these favourable conditions grass produce is taken, instead of for one, for two, or three years in succession. When the conditions for grass-growing are most favourable, as on heavy soils in Western and Northern Britain, the land may be left in grass altogether—in permanent pasture, as this is called.

If nitrogenous compounds are abundant, the grass portion of

the crop prevails; if lime and potash compounds are abundant and nitrogen scant, clover is most favoured, and the grass, stunted and more fibrous. The fit successor for a grass crop, which partially cleans the land by shading, and which ameliorates its character as regards nitrogen and mineral compounds, is a fouling nitrogen-demanding cereal.

5. Cereal Crops.

Duration.—Cereal plants develop all their buds into branches, run them into ear, and exhaust all in grain production within a single season of growth. Duration is, accordingly, annual. Grain is the object of cultivation, and the crop must be allowed time, not only for vegetation, but time for grain formation and maturation as well.

The art of the breeder has, in many cases, modified the natural period of vegetation, spring to summer, and has produced varieties with an extended period, sufficiently hardy to withstand the cold of winter. These winter cereals with a lengthened period of growth, are able to utilize more soil substance and more heat and light, to assimilate more carbon dioxide—to produce, in short, more organic substance of more suitable composition for purposes of nutrition.

The order according to period of vegetation is:—

1. Spring cereals—spring sown.
   (*a*) Barley, shortest period.
   (*b*) Oats.
2. Winter cereals—autumn sown.
   Winter wheat—longest period.

This same represents order of sowing—barley last, winter wheat first.

Root Distribution.—From its base near, but below, the surface of the ground, each shoot of a cereal grass produces a set of feeding roots. These root fibres branch freely, and distribute themselves in the surface soil. The minerals absorbed are poured directly into the leafy branch; there is no intermediate tap, as in root crops and leguminosæ. Although essentially shallow rooters, depths of eighteen and even of thirty-six inches have been utilized by cereal roots. Wheat, of longest duration, has naturally the habit of penetrating most deeply, more so than the quick-growing barley, for example. Thus it happens that if two cereal crops have to be taken in succession, wheat and barley are more suitable, since the roots occupy different layers and feed at different depths.

Order of root depth naturally corresponds with period of growth, thus:—

Barley—shallowest roots.
Oats.
Winter wheat—deepest roots.

The deeper the roots the greater is the drought-resisting power. To secure full root formation, so essential for vigorous growth, the young shoots must be kept in most intimate contact with damp earth at the time of root-making; hence harrow and roller are freely applied to the young crop.

Under the influence of frost, surface soil if wet becomes puffed up and hollow. In such ground shallow rooters lose that intimate connection with soil, and that surface dampness which is so essential for the welfare of shallow-rooted plants. By a free use of the harrow and a finish with the roller the first injury may be, to a large extent, undone.

Habits.—*Absorptive Activity.*—Mineral food for cereal crop is wanted from the soil during the growing months of early year before the flowering stage has passed. The feeding roots have the power of preying upon insoluble minerals such as phosphates and silicates containing potash; these are thus "voracious crops." The silica enters with the potash and accumulates most of all in leaf, though largely also in the stem; it serves no useful purpose, and is mere ballast diminishing the nutritive value of the straw. From the high percentage of silica these may be called "silica crops." The order of voracity for insoluble minerals is:—

Oat—most voracious.
Barley.
Winter wheat—least voracious.

Soils poor for other cereals may thus be rich for oat. Wheat is the most highly cultivated species and the most dainty, requiring the largest amount of soluble material and the best land. The voracity of cereals explains why they can be grown for experimental purposes year after year on the same field.

All cereals must be provided with soluble inorganic compounds of nitrogen, either artificially purveyed or placed at disposal by the process of nitrification, as the result of the biological activity —past or present—of the soil itself. Thus cereals follow roots hoed specially for nitrification, or the nitrogen-purveying clovers. Nitrogenous fertilizers, if applied to meet this want, must be so managed that they occupy the feeding layers at the right time— the layers preyed upon by the feeding roots, containing the

phosphate and the potash compounds, the pure water and the fresh air. The artificial fertilizers must not, as is too often the case, make their way to depths beyond the reach of comfortable root life.

Soil containing much organic substance rich in nitrogen, such as root residue left from grass and clover crops, displays, in early year, the greatest biological activity. From land so enriched and compacted by browsing animals, the largest yield of wheat is got, because of the compact condition, the abundant food at command, and the adequate supply of fresh air and water, all together in right and proper places, suitably proportioned and ready for utilization by the crop.

As the young plant grows older the feeding-ground is changing either horizontally or downwards, thus :—

Barley—horizontal feeding.
Oat—horizontally and downwards.
Winter wheat—chiefly downwards.

As the fibres grow and branch the old parts become impotent as food absorbers, and the young roots of the system are the only feeders. Barley, with its horizontal root spread, is always using the same layer; while oat, with its penetrating root, uses deeper layers as it gets older. Thus it happens that land may grow young oat quite well, but afterwards refuse to bring it to maturity because of the extreme poverty and unsuitability of the deeper layers used during the late and most important period of vegetative life. On oat-refusing land, barley with its horizontal root-spread is the proper crop.

Stem.—Cereal stems are used as litter and as food. The stem takes the form of a hollow straw, solid at the joints. Its skeleton is internal, of fibrous nature, manufactured from carbon dioxide and water, not from silica. The skeleton should be so proportioned that the straw can bear the weight imposed; about 40 per cent. of fibre is sufficient to prevent the bending down or "lodging" of the straw, as the farmer puts it. "Lodging" is the inevitable result when, from over-luxuriance of crop, light cannot reach the base of the straw, since light is specially necessary for the production of fibrous skeleton from carbon dioxide and from water.

Excess of nitrogenous fertilizers is a potent cause of lodging.

When the stem is ripe it is white coloured, hence the designation "white crop."

Branching, or "tillering."—A cereal plant is composed of a set of leafy branches formed in quick succession, and hence of slightly unequal age. The power of producing these branches

—"tillering," as it is sometimes called—is a stem peculiarity; there is no such thing as tillering from the true root in cereals. Power of branching varies thus:—

Oat—least branching.
Spring wheat.
Barley.
Winter wheat—most branching.

The space occupied by the plants depends upon branching power, and the amount of seed per acre is determined thereby:—

	Seed in Rows.
Oat	4 bushels per acre.
Spring wheat	3 ,, ,,
Barley	2½ ,, ,,
Winter wheat..	2 ,, ,,

Winter wheat, if sown so late that branching is not induced till spring, tillers less freely, and becomes, so far as branching is concerned, like spring wheat; and, instead of two, three bushels of seed must be allowed to meet diminished tillering power.

Thick sowing also diminishes branching power, and, by using an extra bushel or so of seed, the crop may be reaped a fortnight earlier, since less time has been spent on branch production.

The branches, as already mentioned, are of slightly unequal age, and consequently the period of maturity is also somewhat unequal. In general such inequality is more marked the greater the number of branches; thus—

Oat—ripens most equally.
Spring wheat.
Barley.
Winter wheat—ripens most unequally.

Leaves.—The leaves are long, narrow, and arranged in two rows; they present a relatively small surface to light and air. The sheath part of the leaf surrounds the stem, and is specially thickened at the base, taking the form of a knot, often described, though quite erroneously, as a stem thickening. The stem within the leaf knot is thinner than anywhere else. Oats have often a touch of red colouring matter developed in the leaf—a sign of their origin from a hardy stock, a hardiness which they still retain above all other cereals.

Ear.—The ear is simple and compact (barley, wheat), or branched and loose (oat); bearded (awned) or beardless (unawned); light or dark in colour. Loose-eared cereals, like oat, mature the grains of the same head most unequally.

Grain.—The grain is naked (wheat) or invested in a husk

(barley and oat); coloured or white; thick or thin, as regards skin and husk.

All the nutriment is contained within skin and husk, the fat chiefly in the embryo, the starch, etc., in the endosperm, and albuminoids in the digestive layer lining the skin of the grain The chief nutritive constituent is starch.

Grain Formation.—The conditions for grain formation are—

1. The accomplishment of pollination and fertilization.
2. Filling up the cells of the grain with a solution of nutriment—the milky stage.
3. Partial solidification, from albumin deposit and starch formation—the yellow stage.
4. Evaporation of the water by dry wind and heat, as well as conversion of amides into albuminoids, to complete hardening of the grain—the dead ripe stage.

Dry wind and heat have therefore much to do with the complete filling and proper maturation of the grain.

Dominant Manurial Ingredients.—The natural tendency of cereal plants, grown in suitable climates, is to convert most of the valuable substance produced by stem and leaf into nutritive grain, and this is indeed the reason why they have been selected for grain crops. Now, nitrogenous compounds favour stem and leaf production as well as branching power, hence under the influence of these fertilizers there is more material for conversion into grain, and the total produce is increased in amount. Cereal crop thus demands from the soil relatively large amounts of nitrogenous compounds in soluble form; hence, again, available nitrogenous compounds are the dominant manurial ingredients of this class of crop. The voracious roots can make thoroughly good use of the innate wealth of the soil, so far as phosphates and potash are concerned, and as a rule they have plenty of time to do so. Under strong nitrogenous influence, the crop may be about a fortnight later, but sufficiency of phosphates checks this retarding action; indeed, grain and seed formation are always favoured by phosphatic compounds. The cereals are appropriately called "nitrogen-demanding crops." The nitrogen demanded by them is supplied, at least to a very large extent, by the dung applied to the preceding crop of roots, or by the residual roots of grass and clover, together with the droppings of the animals.

Requirements.—*Soil.*—The longer the period of vegetation, the heavier is the land which suits the crop:—

Barley—light land.
Oat.
Winter wheat—heavy land.

Barley grows quite well on heavy land; then it is slower, thicker in husk, more nitrogenous in grain contents, and suitable for feeding, not for malting.

Wheat preponderates on heavy soils, often called "wheat lands," by reason of their special suitability for this crop. Of all cereals, oat has the widest soil range because of its hardihood; its voracity suits for poor land, and its penetrating roots for the very heaviest soil textures. For purposes of reclaiming moor and bog land, oat cannot be surpassed.

Climate.—The object of grain-growing is the production of a dry product which will keep and sell. Hence dry wind and high temperature are required, more especially for maturation in July and August.

Varying as they do in period of growth, cereals require different amounts of heat, those that grow longest, most:—

Barley—least heat.
Oat.
Winter wheat—most heat.

Barley can be grown furthest north, because its short period of growth allows of sufficient extension to compensate for diminished temperature. The heat requirements of wheat are scarcely fulfilled in northern Britain, and hardly even in the south.

Character in Relation to Soil.—Cereals are—

1. Exhaustive.
2. Fouling.

They are exhaustive because the grain is sold off the farm. Among all the crops of a rotation, the exhaustive character of the cereals is most marked.

The crop must be so grown that light has access to the base of the culms, and to the ground: no cultivation can be carried on after the plants have passed their first stage of growth. Underweeds, though not destroyed, are weakened and "drawn up."

Cereal production thus involves the growth of ameliorative and cleaning crops requiring much dung, such as roots, grass, and beans; with these, cereals must alternate. This rule is broken when barley, for malting, follows wheat.

Chemical Composition of Grain.—Grains are dry products, which contain water, imbibed in their organic substance to the extent of about 15 per cent.; dry air cannot evaporate this imbibed water. Chemical composition depends upon period of vegetation; percentage of ash, manurial value, albuminoids, fats, nutritive value, and albuminoid ratio increasing with it; thus—

Barley—least valuable.
Oats.
Winter wheat—most valuable.

Selection has, however, modified the value and composition to a considerable extent: thus, the ash of wheat may be reduced below that of oat, and the albuminoids of wheat in the same way; the fats may be considerably reduced, as in wheat and barley; the fibre may be reduced, as in wheat and barley; the carbohydrates may be increased at the expense of albuminoids, as in the same two crops; and so forth.

The composition depends upon the period of vegetation, and that in turn upon the breed, the soil, and the climate.

Fine wheat is less nutritive than coarse wheat, fine barley than coarse barley, and so on. This explains why the results obtained by different authorities are so conflicting; composition and nutritive value depending upon the breed, as well as upon the soil and climate in which the sample analyzed has been grown.

Variations within the following limits occur—

Ash	$1\frac{1}{2}$ to 3	per cent.
Nitrogen	$1\frac{1}{2}$ to 2	,,
Albuminoids (N × 6·25) ..	9·37 to 12·5	,,
Fats	1·5 to 6	,,
Carbohydrates	56·00 to 66	,,
Fibre	3·00 to 9	,,

The albuminoid ratio often is—

Barley	1 : 6·8	lowest ratio.
Oat	1 : 6·7	
Winter wheat	1 : 5·4	highest ratio.

Composition of Cereal Straw.—Like grain, straws are dry products, and contain from fourteen to fifteen per cent. of imbibed water. Chemical composition depends upon period of vegetation: percentage of ash, manurial value, albuminoids, fats, nutritive value, and albuminoid ratio increasing with it. Selection has considerably modified the composition, especially of wheat; its straw has least ash, least manurial value, least nitrogen and albuminoids, least nutritive value, most carbohydrates, and lowest albuminoid ratio. Breeders have taken care to secure varieties of wheat which, properly grown, leave least valuable material in the straw.

The variations are—

Ash	4 to 5	per cent.
Albuminoids	3 to 5	,,
Fats	1 to 2	,,
Carbohydrates	38 to 35	,,

Period of Highest Nutritive Value.—A cereal crop is known to be dead-ripe when the green straw has passed through the

yellow colour, and become white. The grains have just solidified when the straw is becoming yellow, but they are harder when it has become white.

For sowing or malting purposes, grain should be taken when thoroughly mature, because of better germination and extra production of diastase. Accordingly, barley for malting should be cut when the grain is quite hard and the straw white. For flour or meal-making, the crop should be taken when the grains have solidified, before they become hard. Loss of grain through shedding is thus avoided, and straw of higher nutritive value secured.

Chemical Changes in Ripening.—Ripening starts when transfer of material from stem and leaf to grain begins. At this period there is, accordingly, great change in the situation and chemical condition of the various components of the plant. Substances formerly kept separate, now act and react freely upon one another: thus chlorophyll, in stem and leaf, played upon by acid, begins to change from green to yellow and from yellow to white substances as the reaction approaches completion; the condition of the chlorophyll is indeed the indicator of the degree of ripeness.

Much material, formerly in solid form, is converted into a fluid stream composed of—

1. Water, phosphates, and potash compounds.
2. Sugar very largely, and fats.
3. Organic substances containing nitrogen—amides and albumins.

The sweet, milky fluid makes its way into the developing grain, and gorges the tissues in the interior; this is the milky stage. The fat is principally laid down in the embryo, while the albumin is precipitated chiefly in the cells of the endosperm by evaporation of water from the exterior of the grain. In the endosperm, too, the starch builders are at work, transforming the sugar into solid starch granules. At this stage, the grain is partially solidified from the albumin deposit and starch formation, the straw is yellow. More water is evaporated, and albumins deposited largely in the digestive layer next the skins. Maturation is now complete, the grain is perfectly solid and hard, and the straw white.

As the grain is being matured, the straw loses the nutriment it formerly held. When the amides have gone from the straw, sugar and nutritive carbohydrates are still left behind; these, now no longer kept in check by amides, rapidly become converted into fibre. To secure nutritive straw the crop is cut when the amides have entered the grain—that is, when the ear is beginning to turn yellow.

Principles of Cultivation.—The principles underlying the production of the best and largest crop are extremely simple. On light land, the wheat crop may with advantage be slightly dunged after grass. Preparation of seed-bed, sowing and harrowing in the seed, and a few turns of the roller, during early growth, complete the cultivation. The seed must be thoroughly ripe, as heavy as possible, properly selected, and come from the most suitable soil and climate.

The *soil* must be clean, well tilled, and deeply cultivated, so that the plant roots are comfortably quartered, neither injured by wet nor drought, well supplied with fresh air, and adequately provided with manurial ingredients. Compact condition of the land is very necessary to protect the shallow roots from drought.

The *seed* should be sown in rows to secure the best depth and most uniform germination, to allow light to have freer play upon the strawy stem, and to lessen the danger of "lodging." By sowing in rows, one-third of the seed is saved.

The *crop* must not be too heavily dunged; if so, it is endangered by lateness, and is more liable to lodge. Phosphates are always safe manures for cereals.

The proper *place in rotation* is after roots, grass, or beans, all of which may be suitable preparatory crops. Barley for malting may, at times, follow wheat on land over-rich in nitrogenous compounds.

Influence of Climate on the Perfection of Growth.—*Barley*, although capable of growing furthest north, is thereby rendered unfit for malting. The cell walls of the husk become too thick, and the contents too nitrogenous.

Oat reaches greatest perfection in Scotland, and ripens its grain in moist climate.

Wheat, requiring the highest temperature, can scarcely be grown to perfection except in the south. Wheat and malting barley are the prevailing crops of the south and south-east.

The general effect of moist or of cold climate is to diminish the proportion of grain, and to increase the straw.

Combined Influence of Soil and Climate.—(*a*) *On Systems of Husbandry.*—The dry climate of Eastern Britain is most suitable for grain-growing; barley, oat, wheat is the general order from north to south. Barley and oat prevail on lighter land; on heavy, wheat. In moister climate, and on the toughest soil, oat is the most suitable species.

Species and varieties with bearded or with coloured ears are most primitive and most hardy, more leafy in their nature, stronger in straw, and exact least from soil and climate. Coloured

grains, thick skins, and husks are also indicative of hardy and less exhausting character.

As the period of vegetation lengthens, the proportion of straw to grain increases; thus—

Barley	.. .. ..	50 per cent. of straw by weight.
Oat	.. .. ..	63 ,, ,, ,,
Winter wheat	.. ..	67 ,, ,, ,,

The tendency, too, of lengthened period is to increase total weight of crop, and to produce grains containing more nitrogenous compounds, thicker in skin and husk.

The great principle underlying cereal cultivation is *alternation with ameliorative crops*—that is, with roots, grass, or beans. Thus on light land the rotation is—roots, grain, grass, grain; on heavy land—roots, grain, grass, grain, beans, grain. In districts suitable for the crop, it occupies half the arable area.

(*b*) *On Malting Barley.*—For fine malting barley the grain should be uniformly ripened; should contain as much starch as possible, and a minimum amount of nitrogenous compounds, especially of amides, which cause troublesome fermentation. Colour, of course, depends upon the nature of these contents, and is accordingly an important indicator of malting quality. For malting purposes, too, a thin husk is very necessary, not only because the proportion of starchy contents is greater, but because of the more uniform and rapid germination of such grains, since rate of water entrance during germination is determined by strength of skin and husk.

To secure these points of character, the sowing must not be too thick; the period of vegetation must be as short as possible—that is, the climate must be warm and dry, the soil of light but compact texture, and not too rich in nitrogenous compounds. Thorough maturation must be reached before cutting.

(*c*) *On Nutritive Value of Oat and Wheat.*—For high nutritive value, the period of growth should not be passed over too hastily. There can be no danger of this in the case of wheat grown in Britain; but with oat it is otherwise. In the moist, cold climate of Scotland, on rich land, the oat ripens slowly, and has time to consume and incorporate in its substance much nitrogen. Under these conditions, there is sufficient time for maturation; highest proportion of albuminoids and highest nutritive quality are thus got. It is different with wheat. Its finest qualities can only be brought out on land comparatively poor in nitrogen, in warm, dry climate. In flour-making, the digestive layer, rich in albuminoids, is removed with the bran, and most of the fat with the embryo plant. Thus the finest wheat-flour is of lower nutritive value than oatmeal.

(*d*) *On Nutritive Value of Straw.*—When from any cause the period of vegetation is prolonged, bulk and nutritive value of straw are greater; for example, oats grown in the cold moist climate of Scotland. The less the grain product, and the less mature at cutting, the more nutritive is the straw. Malting barley, for example, is most mature at cutting, and produces the largest proportion of grain, accordingly the straw is least nutritive. Bean straw is usually much more nutritive than that of cereals.

The order usually is—

Bean straw—most nutritive.
Oat straw.
Wheat and barley straw—least nutritive.

6. Leguminous Seed Crops.—Beans.

Duration.—Beans have no organ of vegetation used specially for storage, and no reserve stock of buds; accordingly they are of annual duration. Some varieties are more hardy and stand a mild winter. Those are autumn sown. Two kinds are thus distinguished—

1. Spring bean—sown in spring.
2. Winter bean—sown in autumn.

The spring bean is sown specially early; this can be done with impunity, as the seed germinates at low temperature, and the seedling is little liable to frost injury. The period of growth is long, often about eight months, hence the early sowing.

The autumn-sown beans are usually ready for harvest in August, while the spring crop is ripening.

Root Distribution.—The root system is composed of an elongated tap, which usually descends into the subsoil with abundant feeding fibres, arranged in several longitudinal rows along its sides. Among cultivated plants, beans and clover are the "miners" which exploit the subsoil with their deep roots. The fibres are branched and loaded with the nodules, or tubercles, so characteristic of leguminous roots.

The proportion of root to air parts is remarkably high—1 to 3, as against 1 to 9 in vetch. This high proportion of root specially rich in nitrogenous compounds renders beans, like clovers, fit precursors for wheat and cereal crops in general.

Habits.—*Feeding.*—Three features connected with the feeding are of special importance:—

1. The peculiar power of fully satisfying nitrogenous wants from the free and uncombined nitrogen contained in the atmosphere of the soil.

2. The extraordinary voracity for insoluble minerals, such as phosphates, and silicates containing potash.

3. The surface soil is less utilized than the deep layers and subsoil.

From these characteristics, beans and leguminous crops are rightly called "the stone-breakers and miners." The extent to which beans prey upon insoluble minerals can only be compared with the similar property of wild grasses and cereals, such as oats. There is this important difference, however: grasses take in useless ballast in the shape of silica, but beans and leguminosæ keep such rubbish out, and are non-silicated crops; this has much to do with the higher nutritive value of the latter. As in oats, so here, voracious feeding is associated with large produce. Thus a good crop of oats or beans yields alike 1 ton of grain and $1\frac{1}{2}$ tons of straw. The excess of straw over grain is determined in both cases by the long period of vegetation; and if by any cause, such as excessive nitrogenous manure, or wet, or cold, this period is further lengthened, the straw is proportionately increased.

Stem.—The stem is stout and firm, consequently, so far as tendency to "lodge" is concerned, dung can be applied as lavishly to bean as to root crops. When ripe, the stem becomes black; hence the name, "black crop."

Leaves.—The leaves, broad and compound, expose a large manufacturing surface to light and air—a character in perfect harmony with the large amount of root. The leaf cells contain abundant crystal contents—crystals of oxalate of lime. Leguminosæ are, accordingly, lime plants. The lime is not to be regarded as a nutriment, however, but rather as an antidote to oxalic acid, poison produced, and necessarily produced, by the vital activity of the plant itself. If lime-supply is insufficient to neutralize the acid, poisoning is the result.

Flowers.—The flowers are not aggregated into an ear; some are very low on the stem, others quite high. Lower flowers are evidently older than those above; hence flowering and ripening are very irregular. To give these lower flowers equal chance of reaching maturity, light must have free access, and this is one chief reason for not sowing beans too thickly.

Seed.—No grain-fruit is produced by bean crop, but a true seed, if the terms "fruit" and "seed" are used in botanical sense. In agriculture, "grain" and "seed" are synonymous terms. Accordingly, beans are usually called "grain crops" or "corn crops," since the grain or corn is the special object of the cultivation. The embryo within the seed contains all the nutriment; the seed skin, which envelops, has no nutritive value. In cereal

grains, on the other hand, the embryo contains quite a diminutive portion, chiefly fat, and the main nutriment is in endosperm, a structure unrepresented in the bean. Albumin is the chief constituent, and the albuminoid ratio is accordingly remarkably high—1 : 3 as against 1 : 6 in cereal grain.

Seed formation requires—

1. Insect agency for fertilization.
2. Filling the embryo with a mixed solution of albumin, asparagin, sugar, fat, etc.
3. Partial solidification by deposit of albumin and conversion of sugar into starch.
4. Drying by evaporation, and further hardening by formation of albumin.

Insects, heat, and dry wind are external necessities for seed-production and maturation.

Dominant Manurial Ingredient.—With beans a large crop of seed is procured without nitrogenous fertilizers. Something other than nitrogenous compounds must now be used—something which favours the vegetative processes without giving undue prominence to the straw. Potash compounds favour the manufacturing operations carried on in the leaf workshops, and quite meet the requirements of the case, so far as dominant ingredient is concerned. Beans are thus appropriately called "potash-demanding crops." To aid the conversion of the manufactured products into seeds, phosphates, if at all defective in the soil, may also be used with advantage. Bean roots are, however, most voracious, and have plenty of time for the exercise of this talent; fertilizers are impotent to increase the crop in a soil with innate richness. In cold climate and season, however, potash fertilizers are undoubtedly advantageous.

Requirements.—To satiate the appetite for insoluble minerals and for water, heavy land—from its special suitability called "bean land"—is very necessary. The water ought to be imbibed in the soil-particles and not in the pores plugging them up; this chiefly for the reason that the plant wants nitrogen from the soil atmosphere. Too loose a texture is injurious rather than beneficial, because of the more active nitrification and diminished water supply under such conditions. Sufficiency of lime to neutralize the oxalic poison in stem and leaf is also requisite.

Character in Relation to Soil.—Beans are—

1. Exhaustive.
2. Additive of nitrogen and ameliorative.
3. Cleaning, or may be used as such.

Beans are rightly called "exhaustive" when the soil produce is sold off the farm. The produce of seed per acre carries away

about 21 lbs. of phosphoric acid and 25 lbs. of potash. The bulk of this material has, however, been drawn from the depths, not from surface soil.

Although exhaustive, as just explained, the crop leaves the land much richer in nitrogen than before, and this because the plants have been supplied from the elementary nitrogen of the soil atmosphere. Beans, like clover, are the "nitrogen purveyors" of the farm. Much of this nitrogen is left behind in the large root residue contained in the surface soil.

These surface residues—the crop straw and fallen leaves—also contain much phosphoric acid and potash in readily available form, gathered together by the deep roots in the subsoil. It is a fundamental principle of profitable farming, that soil capital—more especially that in the deeper layers, out of ordinary range—should be in circulation, not dormant and lying idle. Bean crop accomplishes this, transfers insoluble minerals from subsoil, and places them in available forms in the soil itself. Leguminous crops thus enable the farmer to realize the latent wealth of the soil and of the air which it contains; these purvey suitable compounds for the other crops of the rotation. For this, if for no other reason, such crops must be specially attended to by the successful cultivator. From this point of view beans may well be regarded as ameliorative.

Beans can, if desired, be cultivated like root crops, so as to leave the land clean and free from weeds. They can be grown best on condition that the land is clean and kept clean—at least during early life; for, like root crops, they attend specially to downward growth at first, and afterwards extend themselves in the upward direction. When this has taken place, the large leaf surface shades the ground, and tends to suppress bottom vegetation.

If the bean seeds are consumed on the farm, and if the crop is kept clean by cultivation, it may rightly be regarded as a fallow, ameliorating and cleaning the land like root crop itself. If cleanness is not specially kept in view, bean is no fallow crop, but a fouling crop like corn.

In rotation, cleaned beans fitly alternate with shallow-feeding and fouling crops, requiring much available nitrogen, such as cereals.

Chemical Composition.—*Seed.*—Bean seeds, like cereal grains, are dry products, and contain 15 per cent. of imbibed water. Ash, about 3 per cent., is composed chiefly of phosphoric acid and potash, 1 per cent. each. Nitrogen, 4 per cent., is twice as much as in cereals; and the albuminoid ratio is 1 : 2.

Straw.—Air-dry straw contains from 14 to 15 per cent. of water. The ash, 4 to 5 per cent., is composed chiefly of potash

and of lime. Fibre is usually less than in cereal straw, and the albuminoid ratio very much higher. Time of cutting determines nutritive value.

Period of Highest Nutritive Value.—The crop should be taken when the lowest pods turn black—before they open and discharge their seed. In England the leaves are allowed to fall and the stem to blacken before harvesting; in Scotland reapers begin sooner—before the stem darkens, when the hilum (eye) of the seed gets black. In the former case the straw must evidently be much less nutritive than in the latter, since there is little amide left behind to keep fibre-formation in check.

Changes in Ripening.—The changes are of the same nature as in cereals. In the seed there is much more albumin to be dealt with, and the place of storage is the embryo itself; the embryo alone constitutes the whole nutritive part of the seed. Ripening after cutting consists in the conversion of residual amides into albumins. A year in stack is said to be necessary to allow thorough ripening of the beans.

Principles of Cultivation.—Beans are cultivated either on the same principles as roots or as cereals. The seeds are sown in rows, often 20 or 30 inches apart, to allow thorough cleaning and hoeing, as well as free access of light on all sides. Cleaning operations must cease when flowering begins.

Farmyard manure is an immense advantage to a crop like this, taken on a heavy soil, not so much because of food material supplied to the roots, but rather because the dung imbibes into itself the water contained in the pores of the soil, and leaves them free and open to the air. Fresh water in the soil is a fundamental necessity for all crops, but more especially for a crop like this, which benefits by the nitrogen of the soil atmosphere. Ten to fifteen tons of dung per acre may be applied, according to the condition of the land. Fineness of seed-bed is disadvantageous rather than otherwise for the large seed, and consequently large seedling, of the bean—a fortunate circumstance in connection with early sowing on heavy land. Taken as a whole, bean cultivation consists in tilling, dunging, fertilizing, and cleaning during early occupation.

Influence of Climate on Perfection of Growth.—A seed-bed yielding an air-dry product necessitates a dry atmosphere during the maturation period. If drought and heat prevail during flowering, the flowers quickly shrivel up, and have much less chance of insect fertilization; as a consequence, fewer seeds are formed in the pod, and diminished crop results. If wet and cold prevail, the vegetative period is prolonged and the proportion of straw to seed increased.

Systems of Husbandry.—On heavy land, in dry climate, beans

are very essential in rotation, and fitly find a place between the cereal grain crops (suitable for heavy land), such as wheat, or, if the climate is colder, oat. Grass in dry climate is not specially favoured, and, instead of an extra year in grass, beans are often taken. Not only may this be after grass, but between grain crops; thus—roots, barley, grass, wheat or oat, beans, wheat. If the land is rich in nitrogenous compounds, maturity is more slowly reached, and the proportion of straw increased at the expense of seed; hence the best position in rotation is after a nitrogen-demanding crop. Phosphates, however, favour the production of albumins, and keep due check upon nitrogenous action. By the growth of beans, the intervals of recurrence of clover and of roots are lengthened.

The pea serves a similar function on light land; its straw is less fibrous and more nutritive than that of bean.

7. Minor Crops used for Forage.

Forage crops produce stems and leaves, either mown, made into silage, or fed upon the land. From the nature of their produce all are "nitrogen-demanding," except leguminosæ. They are used in two ways:—

1. In place of roots.
2. As catch-crops.

The place of rapid-growing roots, such as turnips, may be taken by rape, and this is accordingly sometimes classed with root, or, better, with cabbage crops, from similarity of cultivation and of produce.

On heavy clays, roots are often very inconvenient, and forage crops of vetches, or mixtures of beans, oats, and vetches may take the place of the fallow crop (roots). After removal of the early forage the land can be cleaned and prepared for wheat.

Many of these minor crops, from the extreme rapidity of growth, are well fitted for interposition between two main crops; such are called "catch," "stolen," or "stubble" crops. The forage "catch" crop is sown in early autumn, and fed off in spring; the land is then prepared for roots. Thus two crops are taken in a single season. This can only be done to advantage on light land, which is easily cleaned, and in warm, mild climates, as in the south of England. The crops used in this way are:—

1. *Forage cereals*—winter rye, winter barley, winter oat.
2. *Forage Leguminosæ*—vetches and crimson clover.
3. *Forage Cruciferæ*—white mustard.

In the Norfolk rotation the "catch" comes in thus—roots, barley, grass, wheat; catch-crop, roots, barley, etc.

It is very evident that no catch-crop can be taken on the barley stubble; the land is already in crop—the grass for next year.

Forage Cereals.—In order of rapidity, these cereals stand thus:—

Winter rye—most rapid.
Winter barley.
Winter oat—least rapid.

These plants are not sufficiently hardy to withstand a severe winter; hence they are only grown in the extreme south. Rye is hardiest of the three, and has a wider range.

Leaf-distinction is easy; thus—

1. Base of blade eared—*barley*.
2. Base of blade earless.
   (*a*) Sheath downy; leaf-blade red—*rye*.
   (*b*) Sheath bald; blade with little or no red—*oats*.

Forage Vetches.—The period of vegetation is about five months. The crop must accordingly be sown as early in August as possible, if intended for use in May. Vetches may, of course, be sown at different times throughout the year, to produce a succession of forage. On heavy land they may occupy the place of roots; in such a case the land must be specially cleaned for the following wheat crop. The plant is deep-rooted, and feeds largely from subsoil layers.

The stem produces scant fibres, so scant, indeed, that an external support is needed to hold the plant up to light and air—the leaf has special tendrils for the purpose. This poverty of fibres is here, as in the pea, a sign of extreme nitrogenous richness, and necessitates growth in mixture with supporting plants, such as rye and oat. Nitrogenous richness, together with the remarkable power of using insoluble minerals, indicates special suitability for making best use of rich land containing lime. Manurial value is very high. Vetches yield an after-crop of branches, and in this respect differ from true annuals.

Crimson Clover.—The period of vegetation is about four or five months. For use in May, sowing may take place in September. This plant lacks the hardiness of winter vetch, and can be grown only in the south, where the winter is sufficiently mild; cold is, indeed, the bane of crimson clover.

The roots are shallow and confine their ravages to the surface soil. This shallow-rooted, top-heavy species, with large leaf surface evaporating much water, requires a soil of specially compact texture, if uprootal is to be avoided and successful growth attained. A white, chalky soil cannot grow the plant at all.

Sufficient heat, water, and compact land are the keys to successful cultivation. Time of cutting is very important; the plant rushes into flower, and drains the nutriment into the forming seeds with remarkable rapidity. Rapid fibre-formation in the stem is the result, and the crop must be taken when the flower heads begin to show. Only a single cut can be got from this clover—a character indicative of a true annual.

White Mustard.—A good crop may be got in five or six weeks.

The roots are deep, and feed chiefly in the deeper layers of soil and subsoil. When sown broadcast it shades the land very completely, starving out weeds. It is not hardy against winter frost, and can only be sown in spring, or in August to be ready by October.

Rape.—A good crop may be got in three months. The hardy species, winter rape, produces bald leaves with waxy skin. Summer rape has rough hairs on the leaf, but no wax. The plants are deep-rooted, the tap root entering the subsoil, and dividing into several branches or fangs. Leafage is remarkably abundant, and likewise the feeding roots,—two points of contrast with its turnip allies. Being provided with abundant feeders, this plant can grow on poor land, such as peaty fens, unsuited to many other crops. It differs from a true annual in yielding an after-crop of branches, or aftermath.

Rape can be fed off clay land by sheep in July, August, September, and October, at a time when no physical injury to the texture results from tread, and at a time which meets the requirements of wheat.

C.—*Seeds.*

Conditions regulating the Vital Power of Seeds.

Vital Power—Germinative and Vegetative.—A seed is said to have vital power when it can pass through the phase of growth called germination. The characteristic feature of this germinating period is that the infant plant or embryo feeds on a mixture of pre-formed organic compounds stored within the seed for this specific purpose. During this phase of life, the embryo plant is comparable to the infant mammal feeding on the milk drawn from the mother's breast.

The vegetative phase of growth succeeds germination. Organic nutriment within the seed has now been consumed, and the seedling product—equipped with vegetative organs for the purpose—uses extraneous supplies of inorganic material drawn partly

from the soil and partly from the air: from these, organic foods are manufactured. Source of food supply is, indeed, the chief distinction between germination and vegetation.

It is wrong to suppose that germination must be finished before vegetation begins—the processes in point of fact overlap one another; before germination is complete the vegetative phase has been entered upon. It is therefore the object of agricultural practice to sow seeds at such a depth in the ground that the conditions of successful vegetation are realized before germination is complete. When this is not accomplished, loss of plants is the inevitable result.

During the period of germination the whole seedling is in the most tender condition, and is most susceptible to disease; hence the vigour and rapidity displayed at this time must be taken into account if a correct judgment regarding subsequent vegetative power is to be formed. To prevent disaster and to secure full and vigorous crops, seeds of the strongest vitality must be sown; the seedlings must be complete and functionally active in all their parts, any imperfections in these respects must seriously diminish the resultant crop.

Construction and Properties of Germinating Seed.—The parts of a mature seed are:—

1. The coat.
2. The food store } Seed contents.
3. The embryo }

It need not concern us here whether the food-store is contained within the embryo itself or within the special tissue called "endosperm." It may, however, be pointed out that in the former case there is no premature birth of the embryo, as in the latter.

The seed must be so constructed that external water and air can pass through the coat and enter into the component cells of the food-store and of the embryo. When water is absorbed the seed becomes turgid, and is said to be swollen. This purely mechanical process of swelling is the necessary precursor of germination; nevertheless it is wrong to conclude that, because the seed swells, it must be capable of producing a plant; something more than water and air absorption is necessary, if the embryo is to pass from the dormant into the active condition of life.

Chemical changes connected with the nutrition of the embryo must take place. This series of changes is initiated by the formation of digestive juice from the contents of a special layer of cells, called by Haberlaudt the "digestive layer." In the grain of wheat, for example, the digestive juice is formed from the contents

of the layer of cells lying immediately within the skin—usually called "aleuron cells"—and the same is the case with all grass plants. When the digestive juice and water pass into the cells of the food-store, the insoluble organic food stuffs contained therein are gradually attacked, and converted into soluble compounds capable of passing through the cell walls. In solution, the organic food stuffs pass out of the store cells, enter into the body of the embryo, serve for its nutrition, and become incorporated in the substance of the various parts of the seedling plant.

The embryo must be capable of undergoing development, growth, and change of form. For the consummation of this series of morphological changes the embryo requires to be living, capable of absorbing water and becoming turgid, capable of utilizing the organic nutriment for growth, and capable of breathing air.

The three fundamental properties of a germinating seed are—

1. It swells.
2. It digests.
3. The embryo develops.

What Germination is.—The process of germination is merely the accomplishment of these changes.

1. Mechanical change—swelling.
2. Chemical change—food digestion.
3. Morphological change—embryo development.

External Conditions necessary for Germination.—To call these properties of germinating seed into action certain external conditions must be fulfilled. Water is necessary for swelling, digestion, and development. The quality of water supplied exerts considerable influence, as is often noticeable in the case of seeds germinated in an artificial apparatus. Hard water, for example, contains lime salts. Those salts may form a coating on the seed skin comparable to the incrustation in a kettle; when this takes place the whole process of germination is stopped. So far as germination is concerned the object is to supply the seed with the purest water possible—rain water meets the requirements of the case.

Air is necessary for the development of the embryo, and for other purposes connected with digestion. If the embryo cannot obtain a supply of air containing oxygen, breathing is impossible, and, as a consequence, development is brought to a standstill. A supply of pure air is, indeed, the key to successful germination. If the air is vitiated with carbonic acid gas the plant is poisoned. During germination large quantities of this poison are evolved

from the seeds—not only from the seeds, but from all decaying organic matter in their neighbourhood. Proper ventilation of the seed-bed must therefore be secured in order to have strong and healthy seedlings. Agriculturalists, as a rule, pay too little attention to the composition of the soil atmosphere, not only during germination, but also during vegetation.

Heat is necessary for chemical change and for development. The rapidity of germination depends upon the temperature: each species has its peculiarity in this respect. That temperature at which germination is most rapid is called "optimum;" below and above this lie the minimum and maximum temperatures at which germination is possible. The germination temperatures for wheat are—optimum, 83° Fahr.; minimum, 41°; maximum, 108°. When seeds are germinated in an artificial apparatus, the temperature is kept constant at 70° Fahr.—a very favourable degree of heat for most seeds.

It is often stated that seeds cannot germinate in light, but such is not the case. Many suppose that seed is buried in the ground to keep it out of the light; the real object is to secure uniform moisture and warmth.

The conditions necessary for germination are—

1. Pure water.
2. Pure air.
3. A certain temperature.

Character and Quality of Seed.

Commercial Seed.—Commercial seed has, in general, the following composition:—

A. Seeds true to kind.

a. Mature { Germinating. / Non-germinating.

b. Immature—chaff.

B. Impurities.

C. Adulterants.

D. Doctored seed.

Germinating and Non-Germinating Seed.—The character of germinating seeds has been already dealt with: they swell, they digest the stored food, they develop the embryo. Mature seeds which do not germinate want one or more of these properties, and may accordingly be divided into three groups:—

1. Hard seeds—cannot swell, or swell with extreme slowness.
2. Dyspeptic seeds—cannot form digestive juice.
3. Dead seeds—cannot develop the embryo.

"Hard seeds" swell, if at all, very slowly, because of the

abnormally dense coat, which retards the entrance of water. Such seeds may lie for months, even years, in the soil before germination takes place, some never germinating at all. In a wet season the percentage of hard clover seeds is usually very high; the white of 1891, for example, often contained 20 per cent. hard. When "hardness" is the only defect it may be partially remedied by scratching or making a break in the skin. In purchasing clover seeds, it is advisable to require from the seller a guarantee of the actual percentage of germination, and to have the percentage of hard seeds stated separately. If the hard seeds are included in the germination, as is becoming the custom, the farmer is liable to be misled.

Grass seeds harvested in a wet season are most liable to dyspepsia. The digestive layer beneath the skin is discoloured, abnormal in composition, and forms little, if any, digestive juice.

A dead embryo, incapable of development, may often be identified by its discolouration, thus :—

Dead wheat embryo—		brown, reddish-brown, etc.
Dead barley	,,	brownish, bluish, dark-coloured, etc.
Dead oat	,,	brownish yellow, reddish brown, etc.

The only certain method of distinguishing the germinating from the non-germinating seeds, is to test the matter by actual germination in an artificial apparatus.

Immature Seed.—Chaff.—There are, of course, grades of immaturity, but here the term immature is applied only to those representatives of seeds which have not developed an embryo plant. Immaturity is only of practical import in the case of grass seeds. It often happens, as in meadow foxtail, for example, that a large percentage of what looks like seed is merely a husk composed of glumes and pales, with no true seed in the interior. This chaff, as it is called, cannot by any possibility germinate, and seed containing a large proportion must have low germinating power. When testing seeds, some botanists pick the chaff out with the impurities before setting the seed in the germinator. The percentage of germination of grass seeds has, therefore, little meaning unless the buyer knows exactly how the chaff has been estimated. This should always be specially borne in mind when purchasing grass seeds.

Impurities.—By impurities is meant all foreign ingredients *naturally* occurring in the seeds purchased. Foreign ingredients include everything which is not the genuine seed; whether more or less valuable than the genuine seed is matter of indifference. Broken seeds though genuine, and those evidently rotten and decayed, are to be regarded as impurity. Some botanists also

regard chaff of the genuine seeds as impurity. The following is a general classification of the most frequent impurities :—

1. Dust, dirt, stones.
2. Seeds—not genuine, weeds, etc.
3. Broken seeds.
4. Chaff of genuine seed.
5. Seeds of parasites, *e.g.* dodder in clover and Timothy.
6. Diseased seeds containing fungi or insects.

Seed Testing.—A glance at the composition of commercial seed shows that it must often be far from perfect. The degree of perfection is capable of fairly accurate measurement, and no one, however experienced, can determine by mere weighing or inspection how much effective seed he has actually sown, or what its money value ought to be, unless special tests have been applied. The farmer too often forgets this, and imagines that he accomplishes his purpose by sowing so many pounds or so many bushels, as the case may be. Evidently the amount of crop does not depend upon the total amount of seed sown ; that portion of the seed which germinates is alone effective for crop production.

Two tests must be applied to the seed before the quantity to be sown can be known :—

1. Purity test.
2. Germinative test.

Purity Test.—When the sample contains dust, dirt, and stones, purity is best determined by weight. The total weight of the sample is taken. Dust and dirt are separated out by means of a sieve; other impurities are removed by hand. The pure portion of the sample is then weighed. Simple calculation gives the percentage weight of impurity. Thus—

Total weight	100 grains.
Weight of pure portion	88 grains.
Weight of impurities	12 grains.

The percentage of impurity is in this assumed case 12 per cent., and the purity 88 per cent.

It is, as a rule, advisable to state the percentage of foreign seeds present by *number*, not by weight. To do this an average sample is taken, say 500 seeds in all. These are looked over under a lens, and the foreign seeds, say 60 in number, are picked out. If 60 foreign seeds are contained in 500 seeds of the sample, the percentage impurity by number is evidently 12 per cent., and the purity 88 per cent.

When purchasing seeds the buyer must know whether the purity has been measured by *weight* or by *number*, and, in the

case of grass seeds, whether *chaff* has been included in the impurity.

Germination Test.—In connection with germination it is necessary to remember that the pure portion of a sample alone is tested. Many suppose that if the germination is high, say 100 per cent., the seed must be perfect or nearly so. The purity may at the same time be very low, say ten per cent. In this assumed case, the figure expressing germination 100 per cent. merely refers to one-tenth of the whole sample, and gives no information whatever regarding the remaining nine-tenths. It is, therefore, quite important to know, not only the percentage of germination, but also the percentage of purity.

In testing germination, an average sample of 100 genuine seeds is taken. This, with a duplicate hundred, is placed in a germinating apparatus, and the seeds as they grow are counted off. The result of the duplicate tests ought not to differ by more than 3 per cent.

In sending seed or corn to a botanist for testing, the utmost care must be taken to secure a fair and honest sample. In the case of grass seeds, the sample would be drawn from the centre of the sack or bag, and in all cases from the bulk delivered to the purchaser. If anything supposed to be injurious or useless exists in the corn or seed selected, samples should also be sent.

When possible, at least one ounce of grass and other small seeds should be sent, and two ounces of cereals or larger seeds. The exact number under which the seed has been bought (but preferably a copy of the invoice) should accompany the sample.

Grass seeds should be sent at least four weeks, and clover seeds two weeks, before they are to be used.

Quality of the Germinating Seeds.—The quality of *germinating* seed depends mainly upon the following factors:—

1. Pedigree.
2. Age.
3. Size and weight of each seed.
4. Weight per bushel.
5. Smell.

Pedigree and age are dealt with separately.

Theory and practice alike lead to the conclusion that the largest and heaviest seeds yield the best and largest crops. Increased size and weight means increased seed contents—that is, more food, and a larger embryo.

Weight per bushel, when it increases with the size and weight of the individual seeds, gives some idea of the quality. This is, as a rule, the case with cereal and other grasses. The

percentage of water in the seed, however, interferes with the result. Samples containing a high percentage of chaff and immature seeds must have low weight per bushel.

A musty smell signifies that the seed is fungated, and the produce may be more or less unhealthy. A rancid smell from oily seeds indicates age.

Pedigree Seed.

Influence of Pedigree on Seed Quality.—A seed has the property of transmitting to its produce certain peculiarities of its parents—that is to say, certain characteristics are hereditary, and capable of propagation by seed. These hereditary qualities become more and more fixed when perpetuated through a long series of generations. There is always a tendency to revert to the original form, but this tendency becomes less after a time. A great deal depends upon soil and climate: it is vain to expect the best seed from parents imperfectly nourished by the soil, and unfavourably situated as regards climate. Hence cultivation under the most favourable conditions is the key to the production of improved seed of the best quality. The breeder of pedigree seed has not only to cultivate as perfectly as possible; he must at the same time select parents with the most desirable and most suitable properties. By steadily pursuing this policy for a series of years, the cultivator fixes these valuable properties in the embryo of the seed.

Methods for securing Pedigree Quality.—In practice four methods are employed for the production of pedigree seeds. These are—

1. Cultivation in suitable soil and climate.
2. Artificial selection.
3. Variation.
4. Crossing.

Cultivation.—Cultivation has for its object the most perfect nutriment of the plants, and to secure this three points must be specially attended to:—

1. Tillage.
2. Mode of sowing.
3. Manuring.

The soil should be free from weeds, and as deep as possible. Freedom from weeds allows the plant to become most luxuriant and most fertile, while depth of soil regulates the water supply, and prevents injury from excessive or diminished supply of moisture. The seed should, as a rule, be sown in rows: maximum light is thus secured, and assimilation is at its best. The manures

should be so proportioned that the vegetative organs are not excessively developed; in the case of cereals, for example, too much farmyard manure diminishes the yield of seed. The largest and best grain crop is obtained by the use of fine bone meal.

Selection.—Hallett and Hunter were the first to adopt the method of selection, and they applied it with the greatest success to the cereal crops. The best fields, the best ears, and the best grains are selected. The grains are sown under the most favourable conditions. From the produce, the best grains are again selected; by continuing the selection and cultivation for six years, Hunter increased the number of grains per ear of wheat from 90 to 124. A certain permanence is thus given to the selected peculiarity, and pedigree seed obtained. These pedigree seeds, like pedigree animals, require strong and healthy parents as well as care and attention, if good points are to remain fixed (See "Change of Seed").

Commercial pedigree seed is not obtained by hand picking, but the selection is simply made by appropriate cleaning and sieving machines. The mesh of the sieve determines the size of the seed selected.

Variation.—It often happens that when a number of plants belonging to the same species is examined, some exhibit special peculiarities, and are called "sports." Among wheat plants, for example, some may have branching ears; others, peculiarities of colour, and so forth. If seeds of such "sports" are selected and properly cultivated for a series of years, a seed may be secured in which a certain degree of fixity is given to a character, apparently accidental and of no permanence. Patrick Sheriff was the first to apply this method to the production of new varieties. It must be clearly understood, however, that sportive character is a sign of a new breed, and its absence of a fixed and established variety.

Crossing.—For seed production the co-operation of father and mother is absolutely necessary. Unless sperms from the sire enter and impregnate the eggs of the mother, no embryo plant can be produced. The pollen grain, when sown on the stigma of the pistil, produces the father and his pollen tube contains the sperm or male elements. In the embryo sac of the ovule lies the mother with her egg. The embryo is the child formed from the blended egg and sperm, and the resultant seed is the ovule containing mother and child. This being so, it is evident that fathers and mothers may be selected from suitable plants, and the blended product of the sexual act—the embryo—combines in one the characters of both parents. The great

advantage of crossing is that the known and suitable characters of different plants are mixed together and fixed on one individual. This method, when properly carried out, affords the greatest scope for the production of new breeds of pedigree seed. The following cases may be mentioned:—

1. Crossed varieties of the same species give new varieties.
2. Crossed species give species hybrids.
3. Crossed genera give genera hybrids.

The cereals in cultivation are fixed varieties of old breeds. In recent years, however, Messrs. Gartess, of Newton-le-willows, have succeeded in producing and in fixing many new cereal breeds obtained by crossing.

Conditions which determine Effect of Age.—Seeds kept for a series of years gradually lose vitality and germinating power; the very sound of "old seed" is ominous to the farmer. Nevertheless, aged seeds may be capable of germination, as has often been proved by growing plants from old herbarium specimens.

The rate at which vitality diminishes depends mainly upon these three factors:—

1. The character of the season and the ripeness of the seed when harvested.
2. The percentage of water on the seed.
3. The place of storage.

If imperfectly ripened, germination falls off very rapidly with age; and the following example, given by Professor Nobbe, illustrates this.

Red Clover.		Germination.	Hard Seeds.	Rotten Seeds.
Fresh seed	Ripe	88	12	0
	Unripe	48	12	40
Same seed four years old	Ripe	58	2	40
	Unripe	6	2	92

The extremely high percentage of rotten seeds in the unripe four-year-old sample tells its own story.

It is well known that seeds stored away in wet condition become heated. The meaning of this is that oxidation and chemical change, putrefaction and decay are going on. Deterioration—not only rapid but complete—is inevitable under such circumstances, inasmuch as the healthy seeds are attacked and inoculated by contagion from their rotting neighbours. Thoroughly dried seed has these advantages:—

1. It keeps well.
2. It germinates most rapidly in the seed-bed.

In accordance with the above, the seed-store should be dry, well ventilated, and cool: under these conditions, the growth

of fungi and germs is checked, and chemical change remains in abeyance.

Quantitative Decrease in Germinating Power.—It is often assumed that when seed has reached a certain age the power of germination is lost. The following is often said to be the maximum age at which germination is possible:—

Wheat	3 years.
Oats, rye, barley	2 ,,
Turnips	3 ,,
Clovers and grasses	2 ,,

Experiment, however, proves that any general rule must be more or less fallacious; actual germination is the only true and certain test, as shown by the following examples given by Professor Nobbe:—

	Fresh Seed.	Same Seed Three Years Old.
	Percentage of Germination.	Percentage of Germination.
Rye	86	26
Turnips	77	59
Red clover ..	87	51
Timothy grass ..	83	67

Qualitative Changes of Old Seeds.—When seeds become old, they lose the fresh appearance of youth, and often assume a darker or browner colour—the result of internal chemical changes. The symptoms of age are very marked in the case of clovers—the aged betray themselves by their shrivelled appearance, their comparative roughness and want of gloss, their darker colour, and so forth. Colour change not only affects the seed, but extends to the internal parts, involving even the embryo itself.

The colour test of age is not immediately applicable to "grass seeds" inclosed in a husk of glumes and pales. Within, the grain may be quite blackened and decayed, although no sign of this is visible on the husk itself. An error is sometimes made in judging Meadow Foxtail by the colour: when mature, foxtail seed has a dark colour, but many prefer the lighter samples, not knowing that light colour is, in this case, a sign of immaturity rather than of freshness.

Influence of Age on the Produce.—As might be expected, changes in the seed induced by age are not without marked influence on the produce, often very decidedly for the worse. The period of germination is unnecessarily prolonged—the swelling, chemical change, and embryo development being

remarkably sluggish. Time is thus lost at the very beginning, and the prolonged period of germination necessarily increases liability to disease, inasmuch as during this phase of its life the plant is in the most tender and susceptible condition. Many of these weaklings must succumb to disease, and spread the germs which they brew, broadcast upon their more healthy neighbours, which in turn succumb. It is, therefore, a most reprehensible practice to mix old seed with fresh: no farmer and no seedsman should under any circumstance do this.

Although age has put its mark upon the seed, vitality may not be completely destroyed. When the embryo is affected, the first part to go is that lying below the cotyledons—the "radicle" it is called. This destructive effect of age is striking when old turnip and clover seeds are germinated in an artificial apparatus. The seed germinates, it is true, but the seedling—if seedling it can be called—wants the parts developed from the radicle, viz. the hypocotyl region of the stem and the primary root. The same is the result in the field, if the cotyledons reach the light,—a lucky accident, since they want the apparatus for lifting them up (the hypocotyl); the seedling may struggle along, and substitute adventitious roots for the tap destroyed by age.

The deteriorating effects of age on the produce may be summarized thus:—

1. Excessively slow and prolonged germination.
2. Liability to disease.
3. Certain parts absent, *e.g.* tap root.
4. Plants relatively small and late.

To secure seed free from these drawbacks, the purchaser must require from the seedsman a guarantee of germination, and check this by a new trial.

In some cases it is not advisable to sow seed which is too new, because it is too rapid of growth and tends to revert to the original form. Excessive rapidity gives a tender plant, more liable to disease than one which grows more slowly and perfects itself as it grows. New swede seed, for example, yields a poorer and more diseased crop than seed two years old.

Old Seed for Breeding Purposes.—Old seed may be used by the breeder for the production of a vigorous and healthy race. Weaklings are killed off when the seed has been kept for a sufficient length of time, and some which survive the ordeal may produce plants specially vigorous and strong.

Change of Seed—why necessary.—An agricultural plant may be regarded as a quantitative machine, capable of turning out definite quantities of starch or sugar, fat, and albumen, in amounts varying with the species. Crop perfection is, however, rarely, if

ever, reached, partly because of season and climatic peculiarities, partly because of the more or less unsuitable proportion of available minerals in the soil; that is to say, the plants are imperfectly cared for and imperfectly fed. Soil defects, though to a large extent under control, cannot be cured till the farmer ceases to use quantities of manure calculated by rule of thumb. He must first know the true composition of his soil—not only the amounts, but the nature of the available stuffs which it contains. So long as he works upon the principle that plants select their food, and bases his manure quantities upon the wide limits allowed by Liebig's law of minimum, or takes them at random, so long must the cost of production be unnecessarily high, and the yield of crop far below that which is attainable. Under these circumstances of defective and one-sided nutrition, the seed product, like the parent plants, must be affected; indeed, it is matter of common experience that seed sown for a series of generations on the same land becomes less and less productive. Prolonged exposure to constant climatic and soil defects fixes certain imperfections in the plants and in the seeds, imperfections which become intensified in course of time. To all appearance, the seed is as good as at first, but the crop diminishes and disease prevails.

The simplest remedy is to give the seed a change of soil and climate—a change of such a nature that improvement, not deterioration, is the result. In the present state of our knowledge, experiment can alone determine which soils are most suitable foı securing and bringing back maximum vigour and productiveness.

Change of seed is necessary under the following circumstances:—

1. When the yield is decreasing without apparent cause.
2. When a better variety can be got than that habitually grown.
3. When the seed is diseased or inferior in quality.
4. When the season is unfavourable for proper maturation.

For one or other of these reasons seed should be changed, but not because others do so. The object in view is to secure a larger and better crop, and the change has no meaning unless this is assured. The first trials ought to be made on a small scale, and when actual experiment proves the advantage the amount can be increased.

Adulterants and Doctoring of Seed.—By *adulteration* is meant the addition of something to the seed for the purpose of gain; by *doctoring*, artificial treatment for the same purpose. Grass and clover seeds, being comparatively small and difficult to distinguish, are most liable to these sophistications. The following cases may occur:—

1. Cheaper worthless seed is added to or substituted for more valuable.

2. Doctored stones are added, *e.g.* stone clovers.

3. Artificial colour is produced.

4. Bad smell is removed by sulphuring, etc.

The most frequent substitutions are—

a. Perennial rye-grass for meadow fescue.

b. Worthless aira for golden oat-grass.

c. Slender foxtail or Yorkshire fog for meadow foxtail.

d. Smooth-stalked for rough-stalked meadow grass.

e. New Zealand tall fescue (*Festuca arundinacea*) for tall fescue (*Festuca elatior*).

f. Common bent, etc., for fiorin.

g. *Anthoxanthum puelii* for *Anthoxanthum odoratum*.

These seeds are distinguished thus :—

Perennial rye-grass : *stalk* broad, flat, tapered to base, no flange at its apex.

Meadow fescue : *stalk* narrow, round, not tapered, flanged.

Wavy hair grass : *awn* basal, straight.

Golden oat-grass : *awn* dorsal, bent.

Slender foxtail : hair on the margins, visible to the naked eye, soft and smooth to the touch.

Meadow foxtail : hair not noticeable ; hard and rough.

Yorkshire fog : *awn* scarcely visible.

Meadow foxtail : *awn* as long as the body of the seed.

Smooth-stalked meadow grass
Rough-stalked meadow grass } only distinguished under the microscope, chiefly by the stalk and hair.

Anthoxanthum puelii : colour, brown.

Anthoxanthum odoratum : colour, almost black.

Artificial colour is given to seed in the following ways :—

a. By sulphuring—bleaching with fumes of sulphurous acid gas (SO_2).

b. By deposition of colouring matter on the surface of the seed.

c. By heating.

White clover is sulphured to give it a light colour and fresh appearance. "Sulphuring" is readily detected by putting the seed in a test-tube with pure hydrochloric acid and pure zinc. Slight heat is applied to the tube, and if the seed has been "sulphured," sulphuretted hydrogen gas (H_2S) is evolved. A strip of blotting-paper moistened with acetate of lead is held over the mouth of the tube, and the sulphuretted hydrogen immediately

betrays its presence by the formation of black sulphide of lead on the blotting-paper.

Artificial colouring matter is readily detected by rubbing the seed with a white moist cloth. The natural colouring matter is in, not on the skin, and, of course, cannot be rubbed off like the superficial matter which has been put on.

Heat is used for giving a darker colour to the seed of *Anthoxanthum puëlii*, so that they may resemble those of *Anthoxanthum odoratum.*

D.—*Weeds.*

A "weed" has been briefly defined as a plant out of place. Morton, in his "Cyclopædia of Agriculture," states that a weed is any plant different from the crop, and growing with the crop to its hindrance. From this we see that plants which may be desirable, say, in pasture, may be ranked as worthless or even injurious on arable land. Our food crops, in order to bring them to their present state of perfection, have been for a long period cultivated under the most favourable circumstances. They have been protected from the other undesired natural vegetation, and hence would not flourish when taken from the care of man and submitted to the test of the "survival of the fittest." The weeds have various means, either by their seed, manner of growth, or other characteristics, by which they become propagated to such an extent as to overpower the more cultivated and delicate plants in the natural state of affairs.

Any observer will have noticed that on certain land and under certain conditions particular kinds of weeds flourish more than others. Again, it will be seen that their habit of growth and other characteristics vary very much. We will now consider a few points of interest with regard to the common farm weeds.

Botanical Position.

Nearly every order has certain members which rank as weeds. In the table at the end of this chapter will be found a list of the chief plant pests, arranged under their various natural orders.

Soils and Situations suitable to Various Species.

Just as some crops thrive better upon a particular class of land, so weeds have their peculiarities with regard to the land on which they grow best. The state of the soil with regard to moisture affects them quite as much as, if not more than, the cultivated

plants. The natural vegetation is also often an excellent guide to the state of fertility of the land. Many weeds are only found growing when the soil is barren; others require the reverse conditions.

We will now give examples of the weeds found on the various classes of soils. Some grow naturally, but others only after cultivation.

On good clay land we find :—

Wild angelica, great spearwort, common sorrel, queen-of-the-meadow, corn cockle, nipplewort, wild chamomile, broad-leaved dock, groundsel, common sow-thistle.

On clays of little depth grow :—

Tussock or tufted hair-grass, corn horse-tail, knot-grass, biting buttercup, charlock or wild mustard, coltsfoot.

On deep clay loams the chief weeds are :—

Scarlet pimpernel, greater knap-weed, toadflax, redshank, bladder-campion, black mustard.

On thin clay loams, besides many of the above, there occur :—

Rest-harrow and hare's-foot trefoil.

On sandy loams with stiff subsoil there are found :—

Mugwort, corn marigold, toad-rush, common soft rush, silver-weed, wild radish or runch, sheep's sorrel.

Besides these, we find on loams generally :—

Fool's-parsley, brome-grasses, shepherd's purse, spurges, fumitories, purple dead-nettle, groundsel, charlock, chickweed, sow-thistle.

On sandy loam, with light subsoil, besides many in the last list, the following may appear :—

Corn centaury (blue-bottle), lady's-mantle, knapweed (hard-head), corn thistle, yellow bedstraw, corn gromwell, corn mint, ragwort, field madder.

Upon sandy soils generally, as well as many of the above, there may be found these common weeds :—

Bent grass, sandworts, hemp-nettle, wall-barley, common red poppy, common knawel, corn spurrey. The viper's bugloss also grows on sandy soils, but is not common.

On the lighter drifting sands grow :—

Sand carex or sedge, sea lyme-grass, sand wheat-grass, hard fescue, yellow bedstraw.

On gravelly land the weeds differ a little from those on sands. There may be found :—

Common bent-grass, silver hair-grass, thyme-leaved sandwort, soft brome-grass, goosefoots, hard fescue, hawkweeds, poppies, knot-grass.

When the gravels are damp, as by the sides of rivers, there occur, besides many of the above :—

Sharp-flowered rush, toad rush.

Alluvial soils bear the following common weeds when in a wet state :—

Marsh bent-grass, common reed, reed meadow grass, round-headed rush.

On limestone soils there abound :—

Creeping bent-grass, upright brome-grass, musk or nodding thistle, greater knapweed, wild chicory, wild scabious, field madder, penny-cress, coltsfoot.

The following weeds are characteristic of chalky soils :—

Pasque flower, stone parsley, woolly-headed thistle, yellow-wort, flea-wort, hawk's-beard, ploughman's-spikenard, dyer's-weed.

Besides the soil, the situation affects the kinds of weeds. Some flourish only on wet land, others on dry; some at high elevations where many would perish. Certain weeds grow luxuriantly only on rich soils, where they crowd out many species, which consequently only show themselves to any extent on poor land. Pastures and arable fields, again, have their respective weeds; and the hedges, woods, roadsides, etc., are the particular abodes of certain of our vegetable foes.

Among the weeds which may be taken as signs of good land are:—

Stinking chamomile, fat-hen or goose-foot, Good-King-Henry, traveller's-joy, fumitory, goose-grass (cleavers), dandelion, corn sow-thistle, chickweed.

The weeds indicative of poor land are very numerous, and are mentioned in the table at the end. The ox-eyed daisy and lady's-mantle show very poor soil.

Peats have their peculiar vegetation. When dry, there may be seen :—

Dog bent-grass, common ling, cross-leaved heath, fine-leaved heath.

When wet, there also occur the cotton grass, cranberry, and spotted orchis; when cultivated, the following weeds flourish :—

Wild oats, soft brome-grass, goose-grass, field scorpion-grass.

In the table at the end of this chapter will be found particulars as to the favourite soil or situation of most of our common weeds.

Manners of Multiplication.

Weeds are multiplied in a variety of ways, the chief of which will now be considered. Thus they may spread :—

(1) by self-sown seed.
(2) by winged seed.
(3) by seed sown with that of various crops.
(4) by being present in manure.
(5) by self-division.

1. This is the natural method of nearly all plants for self-propagation, and the energy is usually concentrated upon the act of flowering and seeding. With annual plants this takes place in the first year of their growth, which is also, as a rule, their last. They grow rapidly, and usually produce a large amount of seed, afterwards dying completely down. These plants form a fairly large percentage of the whole. The amount of seed which they produce is usually larger than that of perennials. Thus each charlock plant has been estimated to produce four thousand seeds. If these and all their descendants grew and were as fertile, then four years afterwards we should have 256,000,000,000,000 seeds—quite enough to take all the profit out of many farms.

Another class of weeds are known as biennials. They are not very numerous, chiefly because of the odds they have to fight against. During their first year they store up nourishment in their roots, leaves, or stems; and in the succeeding year develop a flower-stalk, and bear seed.

In the third class are the perennials, *i.e.* those plants which exist for several years. They usually become of stronger growth than the others; and though they do not generally produce so many seeds each time, yet in the end they leave quite enough descendants.

Seeds do not always germinate soon after they are sown, but may lie dormant for several years, covered perhaps by too great depth of soil. When favourable conditions arise—say, the land is trench-ploughed—then they burst forth in abundance, and have led to the idea held by some farmers that weeds are the direct outcome of the soil. Charlock in particular is capable of existing for many years without germination.

2. The beautiful appendages to the "seeds" of many compositæ (thistles, dandelions, etc.) will have often been noticed. By their aid the seeds are wafted for long distances; and a farmer with naturally clean land may get it weedy through seeds being blown to it from woods and waste places.

3. Since the rules as to purity of seed have been established by the various great Agricultural Societies, impure seed is not so often sold. It was a source of two losses to the farmer—(*a*) he paid for seed he did not want, (*b*) the seeds of weeds germinated and grew quite as well, as a rule better, than the crop, and, to a certain extent, smothered it.

4. Too often weeds are thrown upon the dung-heap, in the belief that they will there decay. Many may perhaps, but others sometimes begin to grow again, and, where they are furnished with thick tap roots containing nourishment, they may perfect their seed and again prove a nuisance. The refuse seeds after threshing are sometimes thrown on the manure-heap, or may be given to the poultry. In the latter case, the larger proportion simply pass through the alimentary canal uninjured. The manure, in both cases, is spread over the land, and a good crop of weeds often results. The remedy would be to burn the weeds and their seeds, though the former might be destroyed in a compost.

5. Couch-grass, coltsfoot, and a few other creeping weeds are propagated in this manner. Couch-grass does not so often flower, though it may be found in hedges flowering sometimes, the head resembling perennial rye-grass. Coltsfoot, however, produces plenty of seed, and has the peculiarity that it flowers early in the year, before its leaves have appeared. It is not very prominent then, and often escapes detection. But besides the production of seeds, they send out long creeping underground stems, from the nodes of which leaves are again given off. Thus large patches of these weeds rapidly form, and such operations as ploughing and harrowing do more harm than good by simply cutting up one plant into several. Each of the pieces is capable of growing and forming another patch. The grubber is the most useful implement to employ in these cases, as it drags the weeds out, breaking them as little as possible.

Methods of Growth.

The various forms of weeds may be conveniently arranged under the following headings: (1) Erect weeds; (2), Climbing and twining; (3) Running; (4) Underground; (5) Spreading; (6) Deep-rooted; (7) Parasitic.

1. *Erect Weeds.*—In this group are included those weeds which have erect stems, and no great expanse of leafage. They, consequently, are not very injurious individually, not taking up much room nor overshadowing the crop to any great extent. When the crop is young they may act detrimentally, especially to a root-crop; but this is chiefly from their vast numbers. They are easily uprooted, but, to compensate for this, their seeding capacity is large. They, consequently, should be pulled up before they flower. Among this group may be placed—

Shepherd's purse, common cudweed, bitter flax, penny-cress, etc.

2. *Climbing and Twining Weeds*, though not very common, are a great nuisance, as they prevent at least part of the crop from

growing well. They either wind their stems round the other plants, or wrap their tendrils round them, and thus pull themselves up. The bramble climbs by the aid of its prickles. In this class are :—

Corn bindweed, great bindweed, goose-grass, birdlip (corn bedstraw), hairy-vetch.

3. *Running Weeds* do harm chiefly by covering ground which might be occupied by more useful plants. They spread rapidly, and are very bad when sown down with clover or such-like crop. They may not show much the first year, but afterwards grow quickly. As examples, may be given :—

Silver-weed, running crowfoot.

4. *Underground Weeds* have creeping stems, which grow under the surface. They are very troublesome, as the stems are easily broken up, and then each piece forms a separate plant. In this group are :—

Corn-thistle, corn bindweed, corn horsetail, yellow toadflax, bracken-fern, couch-grass, coltsfoot.

5. *Spreading Weeds* do injury by covering the ground with the leaves, keeping out the light from the useful plants. They may be divided into two classes, according as they spread their large leaves over the ground, or trail them along the surface. In the first group are :—

Burdock, butter-bur, broad-leaved plantain, docks, coltsfoot.

In the second lot are found—

Goosefoots, ground-ivy, white dead-nettle, broad-leaved toadflax.

6. *Deep-rooted Weeds*, when firmly established, are sometimes difficult to eradicate. They have a deep tap-root, from which numerous rootlets usually branch. Among this class may be given :—

Burdock, spear-thistle, wild carrot, common marsh-mallow, wild parsnip, common dock, field dock, ragwort.

7. *Parasitic Weeds* are, happily, not very common. Among them may be mentioned :—

Clover dodder (*Cuscuta trifolii*), flax dodder (*C. epilinum*), greater dodder (*C. Europæa*), tall broom-rape (*Orobranche elatior*), lesser broom-rape (*O. minor*), branched broom-rape (*O. ramosa*).

The mistletoe (*Viscum album*) is a partial parasite on some trees, such as the oak, apple-tree, etc.

The Dodders. (Natural order *Cuscuteæ*).—The seeds of the clover dodder are small, rather flat, often wrinkled, and are of a pale-brown colour. As they may be readily separated from clover seed, there is no excuse for a seedsman who has any in his samples. The form and life of all three dodders are very similar ;

the first grows on flax, the second on hops and nettles, the last on clover. They are annuals, and must, therefore, grow afresh each year from seed. The seeds consist of fleshy albumin, in which is coiled a spiral, thread-shaped embryo. In spring this germ begins to grow, and a long straight thread is sent out. As soon as the dodder touches the host-plant, it winds itself round the stem, keeping its left side innermost. Should it not meet with any suitable plant it soon dies. In the ordinary case it throws out wart-like suckers, where it touches the stem of the host. They then suck out the juices of the host, gradually weakening it, until it is thoroughly exhausted. The growth of the parasite is rapid. The stem is long, thread-like, has no true bark, and is of a pinkish colour. No leaves are present, or they are represented only by minute scales. Bunches of small reddish flowers, similar in shape to those of the bindweed, occur at intervals on the stems. Each flower produces four seeds. When pulled by the hand the plant is found to be sticky, and has a faint aromatic odour.

The Broom-rapes. (Natural order, *Orobrancheæ*).—The first two attack clover, the third is parasitic on hemp. The *O. minor* is the most common. The seed is sometimes accidentally sown with that of clover. They germinate and become attached to the roots of the crop. The stem has an underground swelling, from which proceed a few roots, attached to those of the clover. The stem is erect, thick, and fleshy, bearing small, colourless, pointed scales instead of leaves. It is from six to ten inches high, and is at first a yellowish-brown colour, turning darker in shade with age. At their free ends are borne the flowers, which are of dirty white colour. They produce oblong capsules, full of numerous minute seeds, very dark in colour. They have a thick, pitted, irregular covering. The *O. elatior* has a stem often one and a half inches in circumference, and eighteen inches or even more in height.

Extirpation of Weeds.

The first point is, of course, to prevent, as far as possible, the seeds of weeds from being carried on to the land. The screenings from threshings should be burned, and on no account put on the manure-heap. Again, the weeds that are growing should not be allowed to seed. They should be cut down or uprooted before they flower. If the weeds are only of annual duration, the land may in this way soon be cleaned, though cutting down may cause them to become biennial.

If annual weeds are well kept down to begin with, until the crop

is of a good height, they can easily be kept in check afterwards, and a good ploughing after the crop has been removed will often free the land entirely. Should the cleaning processes be slovenly carried out, however, the weeds will often overpower the crop.

Root crops and fallows afford good opportunities of cleaning land, and should be taken full advantage of. With the latter, hoeing should commence early, and to favour this, sowing on ridges is often carried out. Carrots, on the flat, are sometimes overgrown by weeds, as their small leaves do not always show sufficiently to allow the hoe to get to work in time.

Biennial weeds need special attention. If the crowns be only partially cut off, they often send out a large number of stems. The flowers on these are not generally so luxuriant as when uninjured, yet altogether they produce a larger number of seeds. Again, when pulled up and thrown on the dung-heap, their thick tap roots contain enough nourishment to enable them to seed.

The plough is a very good means of getting rid of most weeds on arable land. By cutting those with tap roots under the surface they are soon destroyed. With couch and similar weeds the results are by no means so good, and the grubbers do better work.

Hoeing destroys many weeds. This is the best way to clear out most of those with tap roots, which, it must be remembered, should be cut below the crown. A good method to get rid of couch, coltsfoot, and such-like weeds, which generally grow in patches, is to go over the ground, fork in hand, and dig out all the specimens found.

Many of the larger weeds need to be dealt with individually. Some, such as the dock and knapweed, have often to be pulled up by hand. For many of the perennial weeds the spud has to be often used, and the plant may be wholly dug out. Thistles, docks, and knapweeds require this treatment for their removal. Thistles need cutting below the surface of the ground; docks are to be wholly dug out. When pulling out weeds it is best to commence work after a slight shower.

On pastures the weeds are disposed of by digging them up and by frequent cutting, which prevents seeding and gradually weakens the vitality of the plants. A luxuriant growth of grass to a great extent will overpower the weeds, and hence the good done in this respect by a dressing of nitrate of soda on behalf of the grasses, or of phosphates and potash salts for the clovers. When land has been annually cut for hay for a long time, many weeds may become extinct by turning into pasture for a few years.

Liming often reduces the numbers of weeds, and drainage is an excellent means of getting rid of many. Something has been said on this in the chapter on "Drainage."

Green manuring smothers the weeds. It is referred to in "General Manures."

The *parasitic weeds* need special treatment. With clover dodder it has been recommended to eat off the crop with sheep as soon as bare patches begin to show. Then plough the land deeply, and do not take the same crop for many years afterwards. This allows the dodder seed time to die. On no account should action be delayed until the seed be ripened, or the land will get thoroughly foul. It is of no use harrowing the clover to get out the dodder; the pest is simply spread. Watering with a solution of ferrous sulphate (1 lb. to 1 gallon) has been recommended. It is injurious to the dodder, but does not harm the clover.

Broom-rape is very difficult to deal with when once rooted. It must be pulled up with the hand, but the prevention of the sowing of the seed with that of the crop is the chief point to be attended to.

Natural Methods of Extirpation.—Were there not some natural means by which the numbers of weeds were reduced, the farmer would stand a poor chance. If all the seeds produced were to form fresh plants there would soon be a regular wilderness of weeds, but happily they do not. Vast numbers are destroyed by birds and changes of weather. Frosts kill very many; other seeds may drop into unfavourable situations and not be able to grow.

Weeds in a Useful Sense.

Weeds must not be considered as always harmful. When the land is growing no crop, as after harvest, they might well be allowed to flourish were it not for the difficulty of afterwards getting rid of them. Their use consists chiefly in preventing to some extent the loss of nitrates by drainage water. They hold part of this in their tissues, and also do not allow the land to be so readily washed with the rain. The labour involved in afterwards cleaning the land, however, overbalances any benefits received, and weeds must always be looked upon as pests to be destroyed at every opportunity and in any manner possible.

Harm done by Weeds.

This may be classed under the following heads—(1) They occupy ground which should be covered by the crop. (2) They take the soil-substances which would go to make a good crop, consequently the yield is lessened. (3) They may overshadow the more valuable plants and, by keeping out the air and sunlight, cause a poorer growth. (4) They may cling to the

other plants and prevent their full development. (5) They may act as parasites. (6) Their seeds may lessen the value of the produce. Most of these points have been considered, but a few remarks may be made on the sixth. It is chiefly among corn that the ill effects of some weeds are visible. Among the weeds, which are thus so objectionable, are darnel (*Lolium temulentum*), corn-cockle (*Agrostemma githago*), garlic (*Allium oleraceum*), bitter flax (*Linum catharticum*), melilot (*Melilotus officinalis*), goose-grass (*Galium aparine*). The first-named is said to have poisonous intoxicating effects, and the last, when present in quantity, may render oats unfit for feeding to horses. Bitter flax is said to cause purging and scurvy in cattle. The other seeds impart disagreeable flavours to grain, and may prevent it being made into flour.

We now give a Table of the Principal Weeds, arranged according to their natural orders, and with a few particulars about each.

Botanical Name.	Common Name.	Soil or Situation most suitable.	Colour of the Flower.	[1] Time of Flowering.	[2] Duration.
Boraginaceæ.					
Echium vulgare	Viper's bugloss	Upland cornfields	Blue	6–7	B.
Lithospermum arvense	Gromwell	Cornfields	White	5–6	A.
Lycopsis arvensis	Bugloss	,,	Blue	6–7	A.
Myosotis ,,	Field forget-me-not or Scorpion grass	,,	,,	5–7	A.
,, palustris	Common forget-me-not	Damp places	Yellow	7–8	P.
Symphytum officinale	Common comfrey	,, ,,	,,	5–6	P.
,, tuberosum	Tuberous ,,	,, ,,	,,	6–7	P.
Campanulaceæ.					
Campanula hybrida	Harebell	Cornfields	Violet	—	A.
,, patula	,,	Pastures	,,	7–8	B.
,, rotundifolia	,,	Dry banks	Blue	7–9	P.
Jasione montana	Sheep's-bit	Dry hilly pastures	,,	6–7	B.
Caryophyllaceæ.					
Agrostemma githago	Corn cockle	Cornfields	Purple	6–7	A.
Arenaria tenuifolia	Sandwort	Sandy land	Purple and white	6–8	A.
Cerastium arvense	Mouse-ear chick-weed	Cornfields	White	5–8	P.
,, triviale	Mouse-ear chick-weed	Pastures	,,	5–9	A.
Lychnis diurna	Red campion	Hedges, cornfields	Red	6–7	P.
,, flos-cuculi	Ragged robin	Wet pastures	Rose	5–7	P.
,, vespertina	White campion	Sandy land	White	7	A.
Silene inflata	Bladder campion	Damp loams	White	6–8	P.
Spergula arvensis	Corn spurrey	Wet sandy land	,,	7–8	A.
Stellaria glauca	Stitchwort	Moist meadows	,,	6–7	P.
,, media	Chickweed	Arable land	,,	2–11	A.

[1] The numbers express the months of the year, Jan. 1, Feb. 2, etc.
[2] A, annual; B, biennial; P, perennial.

Botanical Name.	Common Name.	Soil or Situation most suitable.	Colour of the Flower.	Time of Flowering.	Duration.
Chenopodiaceæ.					
Chenopodium album	White goosefoot	Waste places	Green	7–8	A.
,, bonus Henricus	Good King Henry	Good land	,,	6–8	P.
,, rubrum	Red goosefoot	Waste places	,,	8–9	A.
Compositæ.					
Carduus acaulis	Stemless thistle	Upland pastures	Purple	8–9	P.
,, arvensis	Creeping ,,	Borders of fields	,,	7–8	P.
,, eriophorus	Woolly-headed thistle	Chalk pastures	,,	8	B.
,, nutans	Musk thistle	Waste places	,,	7–8	B.
,, palustris	Marsh ,,	Moist pastures	,,	7–8	B.
,, pratensis	Meadow ,,	,, ,,	,,	6–8	P.
Sonchus arvensis	Sow-thistle	Cornfields	Yellow	8	P.
,, oleraceus	,, (annual)	,,	,,	6–8	A.
Achillea millefolium	Yarrow	Pastures	White	6–9	P.
Anthemis arvensis	Corn camomile	Cornfields	,,	6–7	A.
,, cotula	Stinking ,,	,,	,,	6–7	A.
,, nobilis	True ,,	Gravelly pastures	,,	8–9	P.
Arctium lappa	Burdock	Waste places	Purple	7–8	B.
Artemisia absinthum	Wormwood	,, ,,	Yellow	7–9	P.
,, vulgaris	Mugwort	Sandy soils	,,	7–9	P.
Bellis perennis	Daisy	Pastures	White and yellow	3–12	P.
Centaurea cyanus	Corn blue-bottle	Cornfields	Blue	7–8	A.
,, nigra	Knapweed	Pastures	Purple	8–9	P.
,, scabiosa	Greater knapweed	Damp loam	,,	7–9	P.
Chrysanthemum leucanthemum	Ox-eye daisy	Cornfields and poor clay pastures	White ray	6–8	P.
Chrysanthemum segetum	Corn marigold	Cornfields	Yellow	6–8	A.
Cichorium intybus	Wild chicory; succory	Sandy land	Blue	7–8	P.
Crepis fœtida	Hawk's-beard	Chalky land	Yellow	6–7	B.
Gnaphalium uliginosum	Marsh cudweed	Wet sandy soils	,,	7–8	A.
Hieracium pilosella	Hawkweed	Dry pastures	,,	5–7	P.
Inula conyza	Ploughman's-spikenard	Chalky pastures	,,	7–8	B.
,, pulicaris	Flea-bane	Moist meadows	Yellow	7–8	P.
Lapsana communis	Nipplewort	Arable land	,,	6–7	A.
Leontodon taraxacum	Dandelion	Moist pastures	,,	3–10	P.
Matricaria chamomilla	Wild camomile	Cornfields	White	6–8	A.
Petasites vulgaris	Butter-bur	Wet meadows	Lilac	4	P.
Senecio Jacobea	Ragwort	Pastures	,,	7–9	P.
,, vulgaris	Groundsel	Cornfields	,,	1–12	A.
Tragopogon pratensis	Goat's beard	Pastures	,,	6	B.
Tussilago farfara	Coltsfoot	Marls	,,	3–4	P.
Convolvulaceæ.					
Calystegia sepium	Greater bindweed	Hedges	White	6–8	P.
Convolvulus arvensis	Small ,,	Cornfields	Pink	6–7	P.
Cruciferæ.					
Alliaria officinalis	Garlic mustard	Hedge banks	White	5–6	B.
Capsella bursa-pastoris	Shepherd's-purse	Cornfields	,,	3–10	A.
Cardamine pratensis	Lady's-smock	Moist meadows	Purple	4–5	P.
Cochlearia officinalis	Scurvy grass	Seashore	White	6	A.
Iberis amara	Candytuft	Cornfields	,,	7	A.
Raphanus raphanistrum	Wild radish or runch	,,	Yellow	5–8	A.
Sisymbrium officinale	Hedge mustard	Commons	,,	7	A.
Sinapis arvensis	Charlock; wild mustard	Cornfields	,,	5–8	A.
Cyperaceæ.					
Carex, sp.	Sedges	Wet places	—	5–8	P.

Botanical Name.	Common Name.	Soil or Situation most suitable.	Colour of the Flower.	Time of Flowering.	Duration.
Dipsaceæ.					
Scabiosa arvensis	Field scabious	Damp loam	Violet	8–10	P.
„ succisa	Devil's-bit scabious	Pastures	„	8–10	P.
Ericaceæ.					
Calluna vulgaris	Ling; heath	Heaths	Rose	6–7	P.
Erica tetralix	Cross-leaved heath	Uplands	„	7–9	P.
Equisetaceæ.					
Equisetum arvense	Corn horse-tail	Wet fields	—	3–4	P.
„ palustre	Marsh „	Marshes	—	6–7	P.
Fumariaceæ.					
Fumaria officinalis	Fumitory	Arable land	Rose	5–8	A.
Gentianaceæ.					
Erythræa centaurium	Common centaury	Pastures	„	7–8	A.
Gentiana campestris	Field gentian	Dry uplands	Purple	9	A.
Geraniaceæ.					
Geranium pratense	Cranesbill	Cornfields	Rose	6–7	A.
„ columbinum	„	Moist pastures	Blue	6–7	P.
Gramineæ.					
Agrostis canina	Dog's bent-grass	Wet soils	—	6–7	P.
„ vulgaris	Common bent-grass	Sandy land	—	6–7	P.
Aira cæspitosa	Tussock-grass	Pastures	—	6–7	P.
Avena fatua	Wild oats	Cornfields	—	8	A.
Briza media	Quaking-grass	Poor damp pastures	—	6–7	P.
Bromus, sp.	Brome-grasses	Meadows, etc.	—	6–7	A or B
Holcus lanatus	Yorkshire fog	Light land	—	6–7	P.
Lolium temulentum	Darnel-grass	Cornfields	—	6–9	A.
Juncaceæ.					
Juncus, sp.	Rushes	Moist land	—	—	P.
Labiatæ.					
Galeopsis ladanum	Hemp-nettle	Cornfields	Rose	8–9	A.
Lamium album	White dead-nettle	Waste land	White	5–9	P.
„ amplexicaule	Henbit „ „	Cornfields	Rose	5–8	A.
„ purpureum	Red „ „	Waste places	Purple	5	A.
Mentha arvensis	Corn mint	Cornfields	Rose	6–9	P.
Nepeta glechoma	Ground ivy	Hedge banks	Blue	4–5	P.
Prunella vulgaris	Self-heal	Damp pastures	Violet	7–8	P.
Stachys arvensis	Corn woundwort	Cornfields	Purple	8–9	A.
Leguminoseæ.					
Melilotus officinalis	Melilot	Cornfields	Yellow	6-7	B.
Ononis arvensis	Rest-harrow	Poor pastures	Rose	6–8	P.
Sarothamnus scoparius	Broom	Stony land	Yellow	5–6	P.
Ulex Europæus	Whin, furze, gorse	„ „	„	2–7	P.
Vicia cracca	Hedge vetch	Hedges	Blue	6–8	A.
„ hirsuta	Hairy tare	„	„	6–8	A.
Liliaceæ.					
Allium oleraceum	Garlic	Cornfields	Green	7	P.
„ vineale	Crow garlic	Meadows	Flesh colour	7	P.
Linaceæ.					
Linum catharticum	Bitter flax	Light land	White	6–8	A.
Onagraceæ.					
Epilobium hirsutum	Hairy willow-herb	Moist land	Red	7–8	P.
„ parviflorum	Lesser „ „	„ „	„	7–8	P.
Papaveraceæ.					
Papaver dubium	Smooth-headed poppy	Cornfields	Scarlet	6–7	A.
„ rhœas	Corn poppy	„	„	6–7	A.
Plantaginaceæ.					
Plantago lanceolata	Narrow-leaved plantain (ribwort)	Pastures		6–7	P.
„ major	Broad-leaved plantain	Pastures and roadside		6–8	P.

Botanical Name.	Common Name.	Soil or Situation most suitable.	Colour of the Flower.	Time of Flowering.	Duration.
Plantago media	Hoary plantain	Pastures		5–9	P.
Primulaceæ.					
Anagallis arvensis	Scarlet pimpernel	Cornfields	Scarlet	6–7	A.
Primula veris	Cowslip	Pastures	Yellow	—	—
Polygonaceæ.					
Polygonum amphibium	Redshank	Wet land	Rose	7–8	P.
,, aviculare	Knot-grass	Moist land	White	7	P.
Rumex acetosa	Sorrel	Everywhere	—	5-7	P.
,, acetosella	Sheep's sorrel	Dry banks	—	5–7	P.
,, crispus	Curled dock	Everywhere	—	6–8	P.
,, obtusifolius	Common ,,	,,	—	7–8	P.
Ranunculaceæ.					
Adonis autumnalis	Corn pheasant's-eye	Cornfields	Scarlet	5–10	A.
Anemone pulsatilla	Pasque-flower	Chalky pastures	Violet	4–5	P.
Myosurus minimus	Mouse-tail	Cornfields	Yellow	5	A.
Ranunculus acris	Biting buttercup	Pastures	,,	6–7	P.
,, arvensis	Corn ,,	Cornfields	,,	5	P.
,, bulbosus	Bulbous ,,	Pastures	,,	6	P.
,, repens	Creeping ,,	,,	,,	6–8	P.
,, ficaria	Pilewort	Hedge banks	,,	4	P.
Thalictrum flavum	Meadow rue	Moist meadows	Ochre	7	P.
Rosaceæ.					
Agrimonia Eupatoria	Agrimony	Borders of cornfields	Yellow	6–7	P.
Alchemilla arvensis	Lady's-mantle	Cornfields	Green	5–8	A.
,, vulgaris	,, ,,	Dry pastures	,,	6-8	P.
Comaridum palustre	Cinquefoil	Boggy places	Purple	6–7	P.
Potentilla anserina	Silverweed	Moist land	Yellow	6–7	P.
Spirea ulmaria	Queen of the Meadow	Moist meadows	White	6–7	P.
Rubiaceæ.					
Galium aparine	Goose-grass; cleavers	Fields and hedges	,,	5–8	A.
,, palustre	Bedstraw	Moist meadows	,,	7	A.
,, tricorne	Birdlip	Cornfields	,,	7	A.
Sherardia arvensis	Field madder	Sandy land	Pink	4–10	A.
Scrophulariaceæ.					
Antirrhinum orontium	Snapdragon	Cornfields	Purple	7–9	A. or B.
Digitalis purpurea	Foxglove	Hedge banks	,,	6–7	P.
Euphrasia officinalis	Eye-bright	Pastures	White	7–9	A.
Pedicularis palustris	Lousewort	Wet pastures	Purple	6–7	A.
Rhinanthus Crista-galli	Yellow rattle	Meadows	Yellow	6	A.
Veronica agrestis	Field speedwell	Cornfields	Blue	4–9	A.
,, hederifolia	Ivy-leaved speedwell	,,	,,	5–8	A.
,, officinalis	Common speedwell	Poor land	,,	6–8	A.
Solanaceæ.					
Atropa belladonna	Deadly nightshade	Waste places	Violet	6	P.
Hyoscyamus niger	Henbane	,, ,,	Straw	7	A. or B.
Umbelliferæ.					
Ægopodium Podagraria	Gout weed	Damp places	White	6–7	P.
Æthusa Cynapium	Fool's-parsley	Cornfields	,,	7–8	A.
Angelica sylvestris	Wild angelica	Damp clay land	Pink	7–8	P.
Conium maculatum	Hemlock	Hedges	White	6–7	B.
Heracleum sphondylium	Hogweed	Pastures and hedges	,,	7	B.
Scandix pecten-Veneris	Shepherd's needle	Cornfields	,,	6–7	A.
Urticaceæ.					
Urtica dioica	Common nettle	Hedges	—	7–8	P.
,, urens	Small ,,	Waste places	—	6–10	A.

E.—*Fungoid Diseases.*

The fungoid diseases affecting plants are numerous and important. It is only within the last ten years or so that some of the most destructive have been properly understood. The researches of De Bary, Pasteur, and others on the Continent, and of Marshall Ward in this country, have removed many difficulties in understanding their nature. And it would be a good thing for the farmers of this country if they knew more of the diseases that affect their crops. If any disease attacks their animals they have the veterinary surgeon to advise them, but so far we have no men who have taken up the profession of diagnosing and treating the diseases of plants.

The fungi are devoid of chlorophyll, and therefore are quite as dependent as the animal kingdom upon green plants for their food.

Some fungi, which live upon dead or decaying organic matter, are termed "saprophytes." Those which derive their nourishment from living animals and plants are termed "parasites."

Saprophytes are comparatively harmless. These are represented by the common moulds and mildews, found on stale bread, old boots, damp fruit, etc. Parasites, on the other hand, attack living animals and plants. Examples of those attacking animals are ringworm and the various specific diseases, but we have especially to deal with those attacking living plants.

Parasitic Fungi are generally degenerated forms. Some are of a destructive, wanton nature, destroying far more than they can feed upon, as the "potato disease," like a tiger that kills for the sake of killing.

Others are of a higher nature, and, without killing the plant, make use of it for their own purposes, like the "ergot." These may be compared to the ants that keep aphides for the sugary secretion they extract from them.

Parasites are generally small colourless plants, which reproduce themselves in two ways: first, by rapid cell-division within the plant they are parasitic upon, and secondly by spores, which they produce instead of seed. These spores are extremely minute, and millions float in the atmosphere unnoticed and unsuspected.

Moisture and warmth are necessary for the development of these spores, so that in warm damp weather, when the spores come in contact with the right plants, they stick to them, and send out small thread-like growths, called "hyphæ." These penetrate the vegetable tissues, and feed upon their juices, increasing in number, till at last the plant dies from the attacks. Before the "host," as the plant attacked is called, is killed, the fungus

usually forms vast numbers of spores, which are thrown off into the atmosphere to seek fresh victims.

The conditions favourable to fungoid attacks are :—

1. Warmth and moisture.
2. Rankness of growth.
3. Unhealthy condition of crops.

A strong, vigorous plant in its natural condition can best resist attacks of disease brought about by lack of proper nourishment, bad seed, stagnant water, and too heavy manuring.

Finger-and-Toe, Club-root, or Anbury.—There are often confused under these titles three forms of disease.

(1) Swellings caused by insect attacks.

(2) Degeneration or partial reversion to wild form. This is due to bad seed, unsuitable soil, and want of proper nourishment. This disease should properly be called Finger-and-Toe, and was recognized as such by the late Professor Buckmaster twenty years ago.

(3) The third form of disease is by far the most important, and is properly called Club-root, or Anbury, although the name Finger-and-Toe is its usual appellation. It is caused by a fungus, enjoying the title of "Plasmodiophora Brassicæ." This fungus attacks all plants belonging to the natural order of Cruciferæ—turnips, swedes, cabbages, radishes, mustard, rape, cauliflower, etc.

If a young turnip or cabbage plant affected by the disease be pulled up, it will be found that the roots are deformed by warty excrescences of all shapes and sizes. Such a plant will be useless for agricultural purposes, for all the nourishment will be absorbed by the diseased portions of the root, which continue to increase in size whilst the remainder of the root is hard and stringy. If the diseased turnips are allowed to take their course, those affected rot and decompose, and any cruciferous plants grown afterwards in the same soil are sure to be affected.

If a thin slice of one of these disease-swellings be examined under a microscope, the cause of the disease will at once be seen. Instead of the ordinary cell structure we find a number of enormously developed, enlarged cells, with their contents consisting of granular slimy protoplasm, which is continually showing signs of movement. These enlarged cells are twenty to a hundred times larger than their usual size, so it can be very well understood how the diseased part becomes swollen. The fibro-vascular bundles are displaced, and the whole structure of the root is disorganized.

If a section be taken later, in the autumn, it will be found that the shiny protoplasm has divided up to form thousands of rounded yellow-looking spores.

If the diseased turnips are ploughed in, the spores are spread

through the land, germinating in spring, and produce creeping or swimming broods of zoöspores.

Zoöspores attack charlock and other cruciferous weeds, selecting the young plant, and entering through the root hairs. They locate themselves in the cellular tissue of the young root, where they commence to feed upon the albuminoids. An analysis of the diseased portion of the root shows a very large percentage of nitrogen, whereas the remaining undiseased portion of the turnip is very fibrous and deficient in nitrogen.

Means of Prevention.—Some time ago the author sent out circulars to various farmers, and advertised for information upon the subject. Over three hundred replies were received from all parts of England, showing the vast amount of damage done by this pest and the anxiety of the farmers to find some means of dealing with the disease. Some of the evidence brought out was extremely interesting; but, although some farmers have been successful in stopping the disease on their own particular farms, no general or radical treatment of the disease has yet been proved to be successful.

Experiments have been tried for some time at the Aspatria Agricultural College for the purpose of discovering some satisfactory remedy for the disease; but such experiments take a long time, and only remedies which have been thoroughly tested ought to be brought forward.

The chief means of prevention will readily occur to any one who understands the nature of the disease. This, like measles, scarlet fever, or any other fungoid disease, is communicated through the agency of spores or germs, and, no matter how favourable the conditions may be for the development of such a disease, it cannot exist without the presence of these spores.

Get rid of the spores. In order to carry this out:—

1. Remove all cruciferous weeds, clearing the hedgerows, etc., of them.

2. Lengthen the rotation. For instance, in the four-course rotation substitute potatoes or some other crop (always excepting the cruciferæ) for turnips, so that you get turnips on the same land once only in eight years.

3. Do not grow another crop of the same order on that land —rape, for example.

4. Burn the remains of diseased turnips, if bad; if only partially diseased, remove them to permanent pasture and feed sheep with them there.

5. Do not feed them to cattle, or, if you do, be careful the manure is not used for turnips, or you will be sure to get the disease.

Remove the *conditions favourable to the spread* of the disease:—

(*a*) By drainage. Get rid of the stagnant water, when the injurious CO_2 and organic acids, together with a large number of disease spores, will be carried away.

(*b*) By treating the land with lime. There is no doubt that turnips on land deficient in lime are more likely to fall victims to the disease. But contrary to the statement of Mr. W. Carruthers in the *Royal Agricultural Society Journal* for 1893, pt. ii., there have been many cases where abundant application of lime has had no effect. Again, if lime is such an infallible cure, how is the occurrence of the disease on limestone and chalky soils accounted for?

Salt has been found beneficial, and gas-lime has been tried by many with partial benefit.

One interesting circumstance, showing how the disease may be spread, should be noted. It was observed and pointed out by the writer that when wool waste had been used as a manure, Finger-and-Toe often followed; and, upon examining such wool, spores of the fungus were found adhering. The sheep feeding on turnips affected by Finger-and-Toe can carry the spores in their wool, and thus the disease is often propagated.

Ergot of Rye (*Claviceps purpurea*) attacks grasses and cereals, apparently transforming the grain into purplish black, hard, horn-shaped bodies. These are called "sclerotium," being the resting-stage of the fungus.

After some months small bodies grow out from the sclerotium, resembling minute drumsticks with violet heads. After a while these heads, or stroma, become studded with small wart-like eminences, each having a minute hole near the apex, leading to an egg-shaped cavity ("perithecium"). These produce long, tubular asci, each containing half a dozen thread-like ascospores. The sclerotium germinates on the ground in July. The ascospores are shot out at the time when grasses are commencing to flower. On coming in contact with the flower of the rye, they give off hyphæ, which penetrate the base of the flower. A dense mycelium soon forms, and, in about ten days, fine hyphæ are seen forming a network over the young ovary, and from the tips of hyphæ thousands of conidia are budded off. The conidia are covered with a sugary secretion like drops of honey. Insects come after the "honey-dew" and carry the spores from flower to flower. When a conidium comes in contact with the base of a young flower, it germinates and pierces in the same manner as ascospores.

After the mycelium has gone on producing conidia and honey-dew for some days, it increases in size, becomes more and more

compact, and the outside turns blue-black; this forms the sclerotium we started with.

The sclerotium falls to the ground just before the corn is ready.

The ripe "ergots" contain certain deleterious alkaloids, which are supposed to cause abortion in animals when eaten, and certainly have a more or less injurious effect.

Means of Prevention.—Drain the land, as the disease is always worse in rainy seasons and on wet land. Rankness of growth also encourages it. It must be remembered that the ergot attacks many grasses as well as cereals, and, to prevent the sclerotia ripening, hay-fields liable to be infested should be cut before flowering, and not after seeding.

The "Potato Disease."—The fungus causing this disease is known as the *Phytophthora infestans*, or *Peronospora infestans*, the former being the more generally received title.

The spores, from which the fungi are developed, are oval in shape. They are extremely minute and light, and consequently able to float in the air until they drop on some leaves. If the conditions are favourable—that is, if the plants belong to the order of Solonacæ, as the potato does, and provided that there be sufficient moisture and heat, the spores germinate. The thread-like mycelia they send out either die or find their way into the interior of the plants by the stomata.

Sometimes the contents of the germ divide into many small spores, each of which is provided with two cilia, or "tails." By the aid of these cilia they are able to swim about on the damp surface of the leaf for some time. Then they settle and send forth processes ("hyphæ") as before.

Inside the leaf the mycelia rapidly branch, soon destroying the part attacked, and turning it black and withered-looking. If a leaf thus affected be carefully examined, it will be seen that the black part is bordered by a line of white, consisting of thread-like processes bearing fresh spores. These are easily detached, and float away to propagate the disease in some other plant.

After injuring the leaf in this manner, the mycelium passes down the stem into the tubers. Here it uses up almost the whole of the starch, converting the potatoes into a black, rotten mass.

By using diseased potatoes for seed the farmer simply assists in spreading the attack, for the fungus rapidly traverses the young plants, and, by sending hyphæ out of the stomata, is able to produce its spores.

Means of Prevention.—Use only sound potatoes for seed, and burn or bury deeply all affected parts, never throw them on the manure-heap. It is also advisable to destroy all the leaves and stems of a diseased crop.

Destroy all weeds of the order Solonaceæ (bitter-sweet, henbane, etc.).

In planting, have the ridges well apart to allow free access of air and light.

A Russian method of prevention is to heat the seed potatoes to a moderate heat in brick ovens. This is said to kill the fungi.

Jansen's system is to bend over the leaves and put four or five inches of soil on the top of the ridge.

Methods of Cure.—Experiments for stopping the disease have been conducted lately, with what is known as the Bouillie Bordelaise mixture. Pure copper sulphate is dissolved in cold water by hanging it in a coarse bag in a barrel. In another tank some quicklime is slaked, and passed through a sieve into the vessel containing copper sulphate. The whole is well mixed up, and applied by the strawsonizer. The proportions are 3 lbs. copper sulphate and 1 lb. quicklime to 20 gallons of water.

The results are not entirely satisfactory, but at least part of the fungi can be cleared off in this way.

The Smut of Corn (*Ustilago carbo*).—This disease is commonly seen attacking oats, turning the grain black and of a powdery nature. This change of colour is really due to the development of the spores. These black spores, under certain conditions, burst and let out numerous colourless germs, which are capable of producing processes. These processes enter the "host" soon after the latter has germinated, and the fungus, having once entered, keeps on steadily growing without its presence being noticed. The mycelia do not remain near the root, but gradually creep upwards until they reach the growing apex of the stem. As the plant begins to flower, the parasite exerts increased activity, using up large amounts of the food material intended for the young grain. The mycelia now almost fill the seeds, and produce great numbers of the black spores; these at first rest on extremely short hyphæ, but, when ripe, are entirely free and able to float away.

Means of Prevention.—As the germs remain on the grain all winter, various methods of treating them then can be carried out. One way is to dissolve 1 lb. of copper sulphate in water, and add this to every four bushels of seed. This, however, slightly deteriorates the germinating capacity. Another method is to steep the seed for a minute or two in water heated to about 130° Fahr. This may be repeated once or twice.

Spring Rust of Wheat.—The fungus causing this is known in the first stage of its life-history as the *Uredo rubigo-vera.* It attacks graminaceous plants, forming minute orange-coloured

spots ("sori") on the leaves during the later spring months. These sori consist of masses of spores borne on short hyphæ, and connected by them with a densely matted mycelium in the leaf of the "host." The spores ("uredo-spores") now ripen, and are wafted about the fields. When they settle upon the wheat again, the spores germinate on the leaf, and send processes into the tissues. Here they feed, finally rupturing the epidermis of the leaf and producing a second crop of spores. These latter are black in colour, and, under the microscope, are seen to be constricted in the centre. Their coats are thicker, and as they remain through winter without germinating, they are known as "resting-spores." They carry on the attack next spring.

The second stage of this disease is known as *Puccinia rubigo-vera*.

Means of Prevention.—Drain the land well, as the attack is worst in damp, sheltered corners. Only clean seed should be used, and mildewed straw destroyed. Mineral manures are of use to the plant in strengthening it to resist the attack.

Summer Rust of Corn.—The first stages of this are known as *Uredo linearis.* It makes its appearance in early summer as yellow spots on the leaves. The spores ("uredo-spores") are oval in shape, and are supported by hyphæ rising from a densely matted mycelium. These hyphæ have ruptured the epidermis of the leaf in order to bear the spores; and this injury, together with the amount of nourishment extracted from the protoplasm and sap of the plant, greatly weaken the host. As in the spring rust, the uredo-spores are soon set free, and, by germinating again on the leaves of the wheat, produce the second or mildew stage. By means of hyphæ the interior of the leaf is reached, the young fungi grow and produce black resting-spores on the surface, rupturing the epidermis again in order to do so. This stage is known as the *Puccinia graminis.* This mildew stage is reached in autumn; and in spring, instead of attacking the wheat directly, it forms a host of the common barberry (*Berberis vulgaris*). Here it produces what is called the *Œcidium berberidis.* It first appears as small yellowish spots, which soon burst through the skin and form little bordered cups filled with a reddish powder, made up of spores corresponding to those produced by the uredo stage. They forward the disease to the wheat again.

Means of Prevention.—Drainage does away with much chance of disease. Affected straw should be destroyed together with all barberry brushes. Only clean seed should be used. Iron sulphate in the form of solution is said to be of use as a steep for the seed.

Hop Mildew (*Podosphæra Castagnei*).—This appears first

as whitish spots on the leaves, and is most dangerous when on the young leaves. The cause of the whiteness is an intricate network of colourless hyphæ and mycelium at the surface. At intervals, small branches, "haustoria," are sent into the leaf. These serve for taking up food, and for fixing the fungus. The hyphæ bear short erect branches, capable of breaking into segments in warm damp weather. These segments (conidia) may float away and germinate on other leaves, where hyphæ, mycelia, etc., are formed as before. In a few weeks, the white patch turns brown, owing to the formation of numerous small spherical bodies, called *perithecia*, or spore-cases. They contain spores "ascocarps." They remain in their shells during winter, and in spring are set free, and again spread the disease.

Remedies.—The chief remedy is to dust the plants with powdered sulphur, by means of the strawsonizer.

Bunt (*Tilletia caries*).—Attacks wheat. The grains have a nasty smell, and are filled with black powdery spores. They are entirely unfit for food. The remedy is pickling with copper sulphate.

CHAPTER V.

ANATOMY AND PHYSIOLOGY OF FARM ANIMALS.

In commencing a study of the animal body it is best to commence with the elementary structures. These may be taken as Cartilage, Bone, Connective tissue, Muscular fibre or flesh, Adipose tissue or fat, Nerve cells and fibres.

Cartilage is a tough, flexible, and elastic structure. It is white or semi-transparent, and when boiled for some time with water it yields a jelly-like substance called "chondrin." Its uses are (1) to form strong yet flexible frameworks, (2) to cover the ends of bones, allowing them to move with little friction. It predominates especially in young animals, nearly all bones being preformed in cartilage.

Bone is a yellowish white, hard, ordinarily non-sensitive structure, composed of about two-thirds mineral matter and one-third animal or organic matter. The mineral matter consists of about two-thirds phosphate of lime, and one-third carbonate of lime. The organic and inorganic matter of the bone are mixed to a certain extent, although there is an excess of organic matter in the centre and in long bones at the extremities. The outer portion of the bone, which is hard and dense, is made of "compact tissue," whilst the spongy portion which is found at the ends and towards the centre is called "cancellated tissue."

In a microscopic section of the compact tissue there will be seen numerous small tubes (Haversian canals) along which minute bloodvessels run from the cancellated part. Around the Haversian canals are small irregular spaces called "lacunæ," arranged in concentric rings. They communicate with one another and with the Haversian canal by very minute canaliculi, which radiate in all directions. The greater bloodvessels pass directly through the bone into the cancellated structure, and then radiate through the compact part. Bones are surrounded by a strong

fibrous coat called the "periosteum," which serves for protection. Bones are either (1) long, as the femur and humerus; (2) flat, as the scapula (shoulder-blade) and bones of the skull; or (3) irregular, as the vertebræ, and bones of knee and hock joints. The functions of bones are (1) to protect various parts; (2) to form a framework for the softer structures; (3) to act as levers in connection with the muscles. Bones are joined together by ligaments to form joints.

Connective tissue is the structure which connects the integuments everywhere with the deeper structures, and penetrates every other tissue. It is made up of white fibres, yellow elastic fibres, and nucleated corpuscles.

Muscular tissue is the part commonly known as flesh. It is made up of fibres of two kinds, voluntary and involuntary. The former are usually under the control of the will, and are also known as striped or striated muscular fibres. Each of its fibres can be teased out into fibrillæ, which can also be split transversely. Each fibre also has a delicate coat, the sarcolemma. The involuntary muscular fibres, which are found in the stomach and alimentary canal, the bloodvessels, the uterus, urinary bladder, and iris of the eye, are made up of elongated pointed cells, placed end to end, and are not striated. Muscles (1) are the active organs of locomotion; (2) perform all necessary operations of the body requiring motion, such as the pumping of the heart, contraction of the stomach, etc.; (3) give symmetry to the body. Muscles are joined to bones by tendons.

Adipose tissue, commonly called "fat," consists of fat-cells joined together by a kind of tissue called "areolar." Each fat-cell contains a nucleus of protoplasm which manufactures the fat globules within. The uses of fat are (1) to store up heat and energy which is set free by oxidation; (2) to protect other parts.

Nervous tissue consists of nerve fibres and cells. Nerve fibres convey impulses from a sensitive portion of the body to a nerve centre, or from a nerve centre to a muscular fibre or secreting cell.

Anatomy and Physiology of Farm Animals.

The Horse, Ox, Sheep, and Pig, are the four most important farm animals. They all belong to the natural order Ungulata—that is, hoofed animals. The horse, however, belongs to the division Perissodactyla (odd-toed), while the remaining three are members of the Artiodactyla (even-toed). The ox and sheep are included in the subdivision Ruminantia; the pig in the Non-ruminantia. In their skeletons and most other points of their structure the sheep and ox are alike.

Bones of the Horse, Ox, Sheep, and Pig.

	Horse.	Ox and Sheep.	Pig.
1. *Bones of the Skull.*			
Occipital	1	1	1
Parietal	2	2	2
Frontal	2	2	2
Temporal	4	2	2
Ethmoidal	1	1	1
Sphenoidal	1	1	1
2. *Bones of the Ear.*			
Maleus, Incus, Stapes, and Obiculare in each Ear	4	4	4
3. *Bones of the Face.*			
Malar	2	2	2
Nasal	2	2	2
Lachrymal	2	2	2
Palatine	2	2	2
Pterygoid	2	2	2
Superior maxillary	2	2	2
Antro ,, ...	2	2	2
Superior turbinated	2	2	2
Inferior ,, ...	2	2	2
Os Rostri	0	0	1
Lower jaw	1	1	1
Vomer	1	1	1
Teeth	40	32	44
Hyoid bone	1	1	1
4. *The Vertebræ.*			
Cervical	7	7	7
Dorsal	18	13	14
Lumbar	6	6	7
Sacral (segments fused into one mass) ..	5	5	4
Caudal (tail)	13 to 20	20	18
5. *Ribs and Sternum.*			
True ribs (pairs)	8	8	7
False ,, (,,)	10	5	7
Sternum	1	1	1
6. *Bones of each Fore Limb.*			
Scapula (shoulder-blade)	1	1	1
Humerus	1	1	1
Radius	1	1	1
Ulna (very small in horse, rather larger in ox)	1	1	1
Bones of the knee (carpals)	8	6	8

BONES OF THE HORSE, OX, SHEEP, AND PIG (*continued*).

	Horse.	Ox and Sheep.	Pig.
Metacarpals (cannon bone)	3	2	
Phalanges { os suffraginis — great pastern; os coronæ — small pastern; os pedis — coffin bone }	3	6	28
Sesamoids	2	6	
Navicular bones	1	0	
7. *Bones of the Pelvis.*			
Ilium (hook bones)	2	2	2
Ischium	2	2	2
Pubes	2	2	2
8. *Bones of each Hind Limb.*			
Femur	1	1	1
Tibia	1	1	1
Patella	1	1	1
Fibula	1	replaced by ligament	1
Malleolar (at base of tibia)	0	1	0
Hock (tarsals)	6	5	7

Bones below the hock are similar to those of the fore-leg.

Below the tarsals of the pig are 29 bones.

The ox has a small bone in its heart.

The ribs of the ox are flatter and more regular than those of the horse. Its sternum is also broad and flat, while that of the horse is keel-shaped.

Horns.—Nearly all cattle, and some breeds of sheep, are provided with horns. The chief polled (hornless) breeds of cattle are the Norfolk red polls, the Aberdeen-Angus, and the Galloways. Horns consist of a hard non-sensitive outer covering, beneath which are the sensitive laminæ covering the bony case in which are numerous hollow spaces (sinuses), communicating with the passages of the nose. Cattle are often dishorned to prevent them goring one another. There are three ways of doing this: (1) to cut through the tip of the horn and then put on a brass knob; (2) to cut through the horn about its middle;

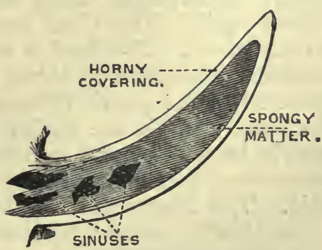


FIG. 31.

(3) to cut through it at its base. The first method is of little use; the second is little better; but the third way is nearly painless, and much the best method.

Digestive Organs and Digestion.—With the horse the food is gathered up by means of the lips, and masticated thoroughly in the mouth. The incisor teeth are used for biting, and the molars for grinding the food. The food is pressed against the palate (or roof of mouth), and gradually acted upon by the saliva. This is an alkaline fluid, secreted by three pairs of glands: (1) the parotid, below the ear, (2) the submaxillary, within the angle of the jaw, (3) the sublingual, under the tongue. Saliva contains, besides water, some mucus and a small amount of a ferment called "ptyalin," which has the power of changing starch into grape sugar. Saliva is also useful as a moistener of the food. The food is then forced back by the cheeks and tongue into the pharynx, from whence by an involuntary action it passes down the œsophagus, or gullet, into the stomach. The stomach of the horse or pig is simple, and of comparatively small size. The mucous membrane lining it is of two kinds: the first is cuticular (like the skin); the second is fine and velvety, and called the "villous." The latter is the true digestive part. In the sheep and ox it is large and has four compartments. With these two animals the food first passes into the paunch, a large strong bag, where it remains until the animal has finished feeding. From this place it then passes into the second stomach, reticulum, or "honey-comb," so called from the appearance of its walls. Here much of the dirt and foreign bodies, which may have been swallowed with the food, are separated out. From the reticulum the fine portions are passed into the third stomach or maniplies, while the rough portion is forced back into the mouth, where it is thoroughly masticated, mixed with saliva, and then passed down into the rumen again. The third stomach is provided with numerous strong leaves. The food is next carried into the fourth or true stomach (abomasum), where it is acted on by gastric juice, secreted by the gastric follicles. The changes in the stomach of the horse and pig are similar to those which go on here. The gastric juice is an acid secretion, consisting of water with small amounts of a ferment, pepsin, mucus, and traces of hydrochloric acid. The albuminoids of the food are converted into soluble proteid bodies, called "peptones;" the casein of milk is coagulated, and changed into peptones. Adipose tissue is disintegrated and the oil liberated. It should be noted that the first three stomachs are merely for storing the food in, and in calves and lambs their services are not required. (The fourth stomach of calves is used for making rennet.) The soluble proteids of the food are absorbed

by the walls of the stomach, pass into the small bloodvessels whence they pass to the liver and thence all over the body. The opening into the intestines (the pyloric orifice), which has hitherto been closed, now opens, and the chyme (partially digested food) passes into the duodenum. This is a curved tube, into which pour two digestive fluids, the pancreatic juice and bile. The latter is secreted by the liver, from which, except in the horse, it passes into the gall-bladder, where it is stored until needed. It is of a brownish-green colour in the horse and ox, greenish-yellow in the hog, and dark green in the sheep. The function of bile is (1) to assist in emulsifying fats, (2) to act as an antiseptic and prevent decomposition, (3) to act as the natural purgative of the body. In its first action it forms a soap with the oil. The pancreatic juice is a colourless alkaline fluid, secreted by the pancreas, or sweetbread, and contains three ferments. The first, amylopsin, changes carbohydrates into sugar; another, trypsin, converts proteids into soluble peptones; the third, steapsin, assists the action of bile in dissolving fats. The chyle, as the food is now called from its white milky appearance, is absorbed by the duodenum, from the sides of which there dip down numerous minute finger-like processes called "villi." These villi have very thin walls through which the dissolved food is readily absorbed. The solution passes into the lacteals of the villi, thence to the Receptaculum Chyli and the thoracic duct, which opens into the jugular veins. The next portions of the intestines after the duodenum are the ileum and jejunum. They are in the form of a long tube many times doubled on itself, held up by a strong fibrous structure called the "mesentery." They have no secretions of any importance. After the jejunum (which ends the small intestines) comes the large intestines. Near their junction is a large blind bag known as the "cæcum." In the ox and sheep, which have extensive stomachs, the cæcum is of a much smaller size than in the horse, where it reaches greater development. Its function is chiefly to store fluids, and it is called the water bag in the horse; it may secrete small amounts of a digestive juice. After the cæcum comes the colon, which has several curves, and finally ends in the rectum. In the colon, digestion cannot be said to take place, although fermentation may occur and cause some of the food to be more soluble. Absorption, however, is very active. From the rectum the fæces are evacuated at will.

The form of the alimentary canal necessarily causes some variation in the amount of food digested. Horses, with their small stomachs, are best adapted for the digestion of concentrated foods (oats, etc.). Cattle and sheep, however, have large stomachs, and are specially suited for the digestion of such bulky

foods as grass, hay, roots. Pigs have small stomachs, but a great length of intestines. Bulky vegetable foods are of little use to them, but they can absorb the nourishment from other kinds of foods very well.

The Liver.—The liver is a large gland situated at the beginning of the abdomen, and lying with most of its bulk on the right side. It is one of the largest bodies which the animal contains. It consists of three lobes, covered by a strong fibrous coat known as the peritoneum. It is very well supplied with bloodvessels, its function being to assist in the purification of the blood. The hepatic artery brings blood to the liver for its nourishment. The portal vein, which consists of the united gastric, splenic, pancreatic, and mesenteric veins from the stomach, spleen, pancreas, and mesentery respectively, brings blood for purification. The liver consists of innumerable hexagonal cells, between which the capillaries run. These cells take out certain substances, and the rest of the blood then passes away by the hepatic vein. From certain of these materials the liver forms bile, thus removing excesses of carbon and hydrogen. The bile is taken away by the hepatic duct, and stored up in the gall-bladder for use during digestion. The gall-bladder is absent in the horse and rat. The liver also forms glycogen, a kind of animal sugar, which it stores up, letting it pass gradually into the blood in small quantities only. A waste of this body is thus prevented.

The Heart and Circulation.—The heart is a hollow muscle of conical shape, lying slightly to the left side of the thorax or chest. It is about eight inches long, and weighs six and a half pounds in the horse. It consists of four chambers, two auricles at the base, two ventricles towards the apex. The left ventricle is the largest, takes in the apex, and has thick strong walls. The blood comes into the heart by the two venæ cavæ, the anterior from the head, and the posterior from the hinder extremities. It enters the right auricle, passes through the tricuspid valves into the right ventricle, from whence it is forced by contraction of the ventricle through the pulmonary artery to the lungs. There it gets its carbonic acid gas changed for oxygen, and comes back by the pulmonary veins to the left auricle. The blood then passes the bicuspid valves into the left ventricle and is pumped all over the body, through the aorta. The various arteries which branch off from the aorta, break up into finer and finer bloodvessels, until they at last have such delicate coats that nourishment can pass from the blood to the various cells, while waste matters are taken up by the blood. These minute vessels are called capillaries. These gradually unite to form veins, which carry the blood again to the heart. The uses of the blood

are (1) to convey nourishment to different parts of the body, (2) to carry oxygen to the various cells, (3) to regulate the heat of the body.

The number of beats of the heart in the horse amounts to thirty-six or forty per minute, in cattle sixty to seventy, in the sheep and pig seventy to eighty.

The Lungs and Respiration.—The lungs are two large elastic structures, situated in the right and left sides of the thorax, and nearly filling that cavity. They are invested with a covering called the "pleura." The lungs communicate with the nostrils and mouth by means of a tube known as the "trachea." This has semicircular rings of cartilage in front, which cause it to have the necessary rigidity. The opening into the trachea is called the "glottis," and is surmounted by a cartilaginous prominence known as the epiglottis. This remains open during respiration, but in swallowing it is pressed down over the opening into the windpipe by the back of the tongue, thus preventing any solid or fluid bodies from entering the lungs. In the first part of the trachea, known as the larynx, the vocal cords or organs of sound are situated. Near the lungs the trachea divides into the right and left bronchi, which enter the lungs and break up into finer and finer bronchial tubes. These end in little air-sacs, and here the exchange of carbonic acid gas contained by the blood for the oxygen of the air takes place. The oxygen is now held in a sort of loose combination by the hæmoglobin of the red corpuscles of the blood, and is carried away by the pulmonary veins to the heart. The blood coming to the lungs is called venous blood, and is of a dark purple colour. That going away is arterial blood, and is bright scarlet in colour. The air passes into the lungs because of the following changes which increase their volume: (1) the diaphragm is drawn back within the abdomen, (2) the ribs are pulled forward, (3) the air rushes in, and the lungs expand owing to their elastic nature. They contract (1) because the diaphragm is brought forward, (2) the ribs are depressed, (3) the atmosphere presses upon them.

The horse breathes ten to twelve times per minute, the ox fifteen to eighteen. The difference between expired and inspired air is that the former contains 4 or 5 per cent. more carbonic acid gas, and consequently that amount less of oxygen. It also contains small quantities of moisture and organic matters. Inspired air consists of 79 per cent. nitrogen, 20·5 per cent. oxygen, 0·04 per cent. carbonic acid gas, and traces of moisture.

The Heat of the Animal Body.—The heat of the animal body is kept up by the oxidation of the carbonaceous matter in the

tissues, and is nearly always the same degree in temperature. The normal temperature of the horse is 100° F., of the ox 102° F., of the sheep 103° F., and of the pig 102·5° F. During the oxidation, the carbon unites with oxygen to form carbonic acid gas (CO_2), while the hydrogen and oxygen combine and produce water. These bodies are taken up by the blood, and got rid of chiefly by the lungs. As the heat of the body must be kept at a constant temperature, certain provisions are made for doing so. Thus, in the hot periods of summer, there is a tendency for the blood to go to the skin, where part of the water, with salts in solution, is taken up by the sweat-glands and poured over the surface of the skin. The extra heat of the body is then taken up in evaporating this moisture. In cold weather the blood leaves the skin somewhat, and hence is not chilled readily. It will be seen that it is best to keep the animal in a place having a mean temperature, and not in one very warm or very cold.

The Kidneys.—The kidneys are two bodies, heart-shaped in the horse, lobulated in cattle, situated in the loins, one on each side of the lumbar vertebra. They are surrounded by a capsule, and are held in their places by their vessels and by areolar tissue usually containing numerous fat-globules. From the concave side of each there descends a tube called the "ureter," leading into the bladder. Each kidney consists of an outer cortical portion and an inner medullary part. The cortical portion contains small bodies (of Malpighi) which take water and various waste matters from the blood supplied by the different branches of the renal artery. This waste material is carried by small tubes into the ureters, and thence into the bladder. It is evacuated from the bladder by the urethra.

The amount of renal excretion varies greatly. In summer with more perspiration there is less got rid of by the kidneys.

The Nervous System.—There are two great systems of nerves: (1) the cerebro-spinal, consisting of the brain, the spinal cord, and the nerves given off from them; (2) the sympathetic, formed of ganglia (knots) of nervous matter, which gives off nerve fibres. Each nerve consists of numerous grey and white fibres bound together by a delicate sheath of connective tissue known as the "neurilemma." The brain and spinal cord consist chiefly of grey matter. There are twelve pairs of nerves coming off from the brain, which carry various impressions to and from the brain or spinal cord. The latter runs along the spinal canal of the vertebra. When a sensation goes to the spinal cord, but not to the brain, and from the former nervous centre an impression goes to the part, reflex action is said to take place. For an

example, prick the limb of a horse, when it will be at once withdrawn. If the spinal cord be cut right through, no sensation is felt and no motion can be performed by the part posterior to the cut. If the inferior roots of the spinal cord at a limb be cut through, the animal will not be able to move that limb, but sensation will be unimpaired. If, however, the superior roots be cut through, sensation is lost in the limb, but motive power is retained. Should half of the spinal cord be destroyed, motion is lost on the side of the cut and sensation on the opposite side.

Hair and Wool.—Hair and wool are the natural protection of the animal from cold, and in consequence of this are always thicker in winter than in summer. Each hair grows from a follicle, which, by producing fresh cells, pushes the previous portion farther out. In the centre of the hair are numerous fibres or elongated cells placed end to end. Towards the outside the cells are flattened and overlap each other in an oblique manner. The cells are cemented together by an adhesive substance which is secreted as the hair grows. The edges of a hair or a wool fibre have a serrated appearance. Both have minute muscles, and also sebaceous glands. These sebaceous glands secrete an oily fluid, constituting the "yolk" of wool, which may amount to half the weight of the wool. The "yolk" consists of (1) suint, a compound of a nitrogenous organic acid with potash, and (2) fat. These disappear when the sheep is poorly fed, and leave the wool harsh and brittle.

The horse sheds his hair twice a year, in spring and autumn. The nourishment in the hair dries up, and thus the hairs shrink and easily fall off. In spring shorter, and in autumn longer, hairs grow. The tail never sheds any hairs.

Wool-shearing usually takes place about May. Sheep are generally clipped when the wool is well "risen"—that is, when it begins to shed.

The Foot is made up of the hoof, the sensitive laminæ, and the bones. The latter are the coffin bone, or os pedis, the navicular bone, and part of the os coronæ. The hoof consists of (1) the walls, which bend round behind, and curve inwards in a triangular manner, forming the bars; (2) the frog, or part between the bars; (3) the sole. The interior of the foot is well supplied with bloodvessels and nerves, and is, on the whole, highly sensitive. The bloodvessels break up into large numbers of capillaries which ramify through the coffin bone, causing it to have a worm-eaten appearance. Near the top of the hoof is a band of tissue known as the Coronary band, which secretes the fibrous tubes forming the horny hoof. This may be torn down as in "treads," thus

causing an imperfect secretion of horn. It should be remembered in shoeing never to pare down too much of the hoof, and not to cut the frog. Just clear away the ragged portion, and never rasp the hoof, as this makes it brittle. The hoof, it may be noted, is made up of minute tubes, running from top to bottom, and containing a gelatinous fluid, which is of great importance in preserving the elasticity of the foot.

CHAPTER VI.

VETERINARY SCIENCE.

All the functions and actions of the living body are more or less due to a stimulus or irritant of a vital character applied directly or indirectly and, to maintain a healthy condition, it is highly necessary that the fluids and solids of the body be of a normal standard. In order to attain this end, certain materials called "foods" are required to replace the ever-changing matters still going on.

The process by which these food substances carry out the above function is termed **Nutrition**; and to have healthy nutrition it is important that—

(1) The structure or parts to be nourished be in a healthy condition.

(2) The supply of blood be not too far away, and be of proper quality.

(3) The heat of the part be of a normal standard.

(4) All the functions should be under the influence of the nervous system.

Circumstances, however, arise which interfere with the equilibrium, and disordered or diseased action is the result. Health and disease, like daylight and darkness, are so blended that we cannot tell where one stops and the other begins.

The first and most extensive interference with this normal state is that of—

Inflammation,

which, like fire and water, is a good servant, but a bad master.

Inflammation is both reparative and destructive. It is reparative when we require its aid in the healing of wounds caused by injury or the surgeon's knife, or in the union of broken bones; and it is the duty of the medical practitioner to keep it

within bounds. Should it get beyond control, its destructive properties are developed, and harm results.

Therefore, inflammation may be defined as an increased nutritive action in the first stage; secondly, as a perverted molecular or structural change in the tissues of the part, with heat, pain, redness, and swelling.

The first action of inflammation is the contraction of the vessels, as witnessed by the sharp cut of a finger—the blood does not flow for a few moments. Next, dilatation occurs, with a crowding of the corpuscles in the vessels of the part, thus blocking up the passage. The corpuscles then become changed, and appear as if glued together. The watery portion (*liquor sanguinis*) of the blood oozes out into the surrounding tissue, the vessels finally give way, the nerves lose their tone, and the part becomes, as if it were, demoralized. That the structures play an important part in inflammation cannot be doubted, as the blood has the same appearance after it leaves the inflamed part as it had before. The various changes mentioned above may be observed very well by pricking the web of a frog's foot with a pin while under the microscope.

Heat is caused by the amount of blood sent to the part, with chemical action and pressure on the nerve filaments.

Pain results from the pressure of the effused material irritating the nerves. It differs in various parts, being sometimes sharp and cutting, again dull, then throbbing and acute.

Redness is due to the accumulation of the red corpuscles and extravasation of the material.

Swelling is due to congestion and exudation. Yet we can have swelling without inflammation, as in dropsy, nettle-rash, and general debility.

Inflammation may be acute, sub-acute, or chronic, and is influenced very much by the nature and temperament of the patient.

In the robust and well-fed we may have it in a *sthenic* form, and in the ill-fed and weak in an *asthenic* form. Therefore the attention of the practitioner has to be called to these various forms, as they require a different plan of treatment.

Every attention must be given towards bringing the disease to a favourable end. The various terminations of inflammation are—

(1) Resolution.
(2) Effusion and adhesion.
(3) Suppuration.
(4) Ulceration.
(5) Gangrene or mortification.

1. **Resolution**—when, by suitable treatment and appliances, the parts have been resolved into their normal condition without injury to the structure or parts. The bloodvessels and blood resume their normal functions, and the effusion is absorbed.

2. **Effusion and Adhesion.**—The former is due to the effused watery portions of the blood, with fibrous deposit, being thrown off into a cavity like the chest, as in pleurisy or injury to a young horse's shoulder from a nip with the collar. Adhesion is seen in pleurisy where fibrous bands are found joining the lungs to the ribs, or in the healing of newly made wounds. It is also seen in joints and sheaths of tendons.

3. **Suppuration.** — Failing to establish resolution, the best endeavour should be made to hurry on the suppurative process, or the formation of matter. In extensive lacerations, cold and hot water, poultices, liniments, and blisters are to be resorted to, according to the circumstances of the case. Personally, the writer is an advocate for the continuous application of cold-water dressings. Not only does it keep the inflammation in check by the endosmotic and exosmotic laws, but it gives tone to the neighbouring structures, and assists in curtailing the spread of the inflammation and in the formation of healthy pus or matter. The best example of an abscess is that of strangles in young horses.

Many *varieties of pus*, or matter, are met with, all of which have a special aspect to the practitioner.

(1) Laudable—fine creamy matter. Most desirable.

(2) Putrid—very rare.

(3) Sanious—mixed with blood.

(4) Scrofulous—watery and of curdy character.

(5) Specific—dangerous and contagious, as it contains disease germs.

(6) Superficial — seen on inflamed mucous surfaces, as in bronchitis.

4. **Ulceration** is an excess of absorption over deposition, with a red, raw, pimply, mattery surface. It is due to a want of tone, and is found in parts of low organization, but is very rare both in horses and cattle.

Stimulating treatment with nutritious diet is to be recommended.

5. **Gangrene or Mortification.**—This constitutes death of a part, and is at times due to intense inflammation, as caused by some extensive injury. It is sometimes seen in mares and cows after difficult parturition. At other times it may arise from a very small wound, which at a glance may appear to be of little consequence, though, from some peculiarity in the system, the disease becomes established. This is the most formidable of all the

terminations of inflammation, and at times taxes the energy of the best practitioner to the very uttermost. In extensive lacerations and injuries the writer prefers the cold-water treatment, as named under "Suppuration."

Hot applications tend to further the process rather than retard it. They relax the neighbouring parts, and prevent the healthy structures throwing off the diseased portions.

When mortification sets in, the wound has a dirty brownish-green watery discharge. The surrounding parts are distended and have a bladdery sound; shivering or rigours set in; breathing fast; pulse small and quiet; cold clammy sweats; head hangs down; septicæmia, or blood-poisoning, having now set in. At this point we are tempted to scarify the neighbouring parts, which should not be done, as it only admits the air to the already diseased structures, and hurries the case to a fatal termination.

Every portion of the body is liable to inflammation. The causes are various—some remote, others apparent. The first object in view in the treatment of inflammation, or any other complaint, is to find out the cause, and, if possible, remove it. The treatment of inflammation is both constitutional and local. Local treatment occurs when you can apply certain remedies directly to the parts affected, as the application of poultices to the feet in Laminitis and Inflammation of the Foot; or in Weed, Inflammation of the Leg, when hot or cold applications are used, with cooling lotions, etc. Constitutional treatment depends on the cause, the temperament of the patient (whether old or young, strong or weak), the extent of the injury or inflammation, the organ affected, and the amount of fever or constitutional disturbance that may be set up. Sympathetic fever is always more or less present when any portion of the body is under the influence of inflammation.

The first object is to remove the patient to a quiet, cool, well-aired loose box. In country practice, taking from four to eight quarts of blood is of great value, if performed early and judiciously. This is more particularly the case when the animal is in too high condition, as we cannot purge our horses and cattle in less than twelve to twenty-four, and even up to forty-eight hours, nor can we make them perspire, as in the human subject. Bleeding, therefore, is of greatest importance in many cases, sometimes acting so well that no further treatment is required. Bleeding should not be resorted to, however, except by the medical attendant, as in many cases it has a very injurious effect.

Purgatives.—No matter what disease an animal may be

suffering from, the action of the bowels is more or less arrested; cattle also cease to chew the cud. The purgatives generally adopted for the horse are aloes, linseed, and castor oils; for the cow and sheep, salts, linseed and castor oils. With reference to administering purgatives to horses, the writer has known a large number of valuable animals killed by the injudicious administration of purgative balls. The safest plan is to give from half to one pint of linseed oil, and call in a qualified practitioner as early as possible.

Town practice differs very much from that in the country. The treatment adopted for country patients would often kill those in towns. The same thing holds good for animals at the bottom of a coal-pit; they have to be treated in a similar manner to town animals.

Simple Fever may arise without any apparent cause, by bringing a horse for the first time from the field to a hot stable, by driving or riding hard, and then putting in a close stable or box; drinking cold water when heated; or standing in a draught. The first symptom to be noticed is shivering, or trembling all over. This may not be seen at the moment, but, when observed, a good stimulant, as warm ale, whiskey, or ginger, should be given. Clothe the body well, and walk the animal about. This may cause the attack to pass off without further trouble; but sometimes the fever runs its course. In such cases the breathing is quickened, the nostrils dilate, head hangs, eye bright and lid red, temperature 104° to 106° F., pulse full and strong. The treatment for this stage is to remove the horse to a cool loose box, clothe well, bandage the legs, allow the animal to drink water with nitrate of potash in, and send for a qualified man. These symptoms may be caused by a debilitating disease, such as pink-eye, influenza, etc. The treatment is very different to that of ordinary fever, having to be of an antiseptic and stimulating character.

Bones.—Like the soft parts, bone is subject to inflammation and its terminations.

When a bone is inflamed to any large extent, and more especially in young animals, bony matter is thrown out. Instances of this are seen in *Splint*, found on the inside of the fore-leg; *Spavin*, found on the lower and inner parts of the hock-joint, joining the head of the shank-bone of the hind limb; also *Ringbone*, on the pastern-joints. Like inflammation in the soft parts, the great point in the treatment is to hurry on the process of resolution, and form pure bony deposit (exostosis). Failing this, should the inflammation be intense, it generally ends in *Caries*, or ulceration of the bone, which has a worm-eaten appearance. This is

found at the hock-joints, backbone, and stifle-joint; in fact, all the bones are subject to this form of disease. The pain in these cases is very acute, and at times causes a great amount of lameness, with annoyance and vexation to the practitioner. However he may treat the disease, it will still continue to run its course, and, if in the neighbourhood of a joint, ends in *Anchylosis*, or stiff joint. In this case the articular cartilages become absorbed, and the ends of the bones unite together.

Anchylosis is most frequently seen in old horses, and found principally in the bones of the back. This renders such animals very difficult to cast, and the operation, if necessary, should always be done with ropes, and not with the hobbles.

Sometimes inflammation of the bone runs on to **Necrosis**, mortification or death of the bone. The dead portion, in some instances, is thrown off and sequestered by a bony deposit forming round it. This at times produces very unpleasant sores, and requires a surgical operation for the removal of the piece.

Rickets, or softening of the bone, is very seldom seen in foals and calves, but frequently in pigs and dogs. It is due to a want of earthy matter in the bone. In these cases it is necessary that the animals have warm comfortable beds, and on no occasion should they be allowed to sleep on stone or flagged floors. Good nutritious diet, with plenty of well-boiled oatmeal porridge and milk, mixed with a little lime-water, must be given. If any febrile symptoms are present, small doses of linseed or castor oil can be administered, following up with half an ounce to one ounce doses of Parish's Chemical Food (syrup of phosphates of potash, soda, lime and iron).

Some breeds of cattle are subject to a disease of the bone and flesh combined, called **Osteo Sarcoma.** It is frequently seen in the bones of the head, jaws, and ribs, and in many cases advances so insiduously and without apparent pain, that all the molar teeth on the side affected fall out before it is noticed. The animal continues to feed, yet gradually loses flesh. There is no cure, the malady being of a cancerous nature.

Fine-bred cattle are subject to scrofulous or tubercular disease of the bones, affecting the knee, stifle, and, in fact, any part of the bony structure. It is frequently found in the vertebral chain, causing partial paralysis of the extremities. In these cases the butcher is of more service than the vet.

The bones of the domestic animals, like all others, are subject to **Fracture.** This may be defined as a forcible separation of the cohesive particles of a hard substance into two or more parts. Fractures are of various kinds.

1. *Simple fracture:* where the bone is simply broken in two.

2. *Compound*—where the flesh is implicated with the broken ends of the bones.

3. *Compound comminuted*—where the bone is smashed into several pieces, and the tissues surrounding it are lacerated.

4. *Complicated*—where the joint or bloodvessels are involved.

Fractures in the cow, sheep, and dog, when of not too complicated a character, are readily reduced, and, with suitable appliance, make good recoveries. Horses, on the other hand, from their irritability, are much more difficult to manage.

Fractures of the bones in the upper portion of the extremities, or those covered with flesh, at times, with care and judicious treatment, mend very satisfactorily. The small bones about the feet also unite, but generally with a stiff or anchylosed joint; and treatment should always be attempted in the case of a good brood mare or sire. The long bones of the extremities, both hind and fore, seldom, if ever, unite kindly, and, if attempted, at times form a false joint. The greater percentage have to be destroyed.

The writer has seen several cases of fracture of the oblique processes of the cervical vertebræ, or bones of the neck, caused by the animal getting the hind-foot shoe fixed in the head-collar. In fighting to liberate itself, it becomes cast in the stall or box, and fracture of the process results. The head in these cases falls to one side in a very peculiar fashion, the nose almost touching the ground, while the side opposite to the fracture is bulged out, the neck having all the appearances of being dislocated. These cases are amenable to treatment. Put on a good double-shanked halter and tie the horse's head on each side, with a strong cradle round the neck.

The treatment of disease or fractures of the bones is, of course, entire rest, cool box, and cold water applications with the hose-pipe or otherwise, until all the inflammatory symptoms are abated. Follow up with blistering or firing, as the case may require. Any constitutional disturbance which may arise must be treated accordingly.

The Horse's Foot.

The late Professor Dick used to say that "the human hand was a subject of much deserved admiration; but the horse's foot is scarcely less an object of wonder. It is also a highly vital and complicated organ, essential to the well-being of the animal, and pre-eminently exposed to injuries. On a minute knowledge of its structure and the uses of its various parts depends the successful treatment of its numerous and important diseases, which, early and accurately discriminated, may often be speedily remedied, while,

mistaken and neglected, they proceed from bad to worse, until the animal is good for nothing."

For the structure of the foot, see p. 219.

On the sides of the coffin bone are two cartilaginous structures, called the "lateral cartilages," which, when inflamed, become ossified and form what are called **Side-Bones.** They are mostly seen in certain cart-horses with good hard flinty hoofs, narrow heels, and high quarters. They are rarely seen in roadsters, carriage-horses, or hunters, or flat-footed cart-horses. As to the cause of the disease, although hereditary tendency may have something to do with it, in the opinion of the writer it is chiefly due to the shoeing of young horses with high-heeled shoes. This removes the frog from the centre of bearing, destroying its function, and throwing the weight on the lateral cartilages. Inflammation, with ossification of these cartilages, is the result.

Owing to the different forms of feet that are met with, and the hard roads on which horses have to travel, shoeing becomes a matter of vast importance. Not only should the shoeing-smith be acquainted with the anatomy and the functions of the different organs of the foot, but he should be able to frame a shoe suitable to any variety of foot, and also punch the nail-holes to the different angles.

Young horses, when brought in from grass for the first time, should not be shod for fully ten days or a fortnight after bringing in from the pasture. The shoes should not on any account be applied when too hot. The writer has seen on many occasions inflammation of the feet, or laminitis, produced by the application of a hot shoe on the same day as the animal was taken from the field.

Laminitis, or *Inflammation of the Sensitive Lamina*, is a very formidable disease, and produced by many different causes—such as overfeeding; drinking cold water when heated; travelling in snow; too much Indian corn, boiled wheat, or potatoes; inflammation going from the lungs or intestines to the feet; over-dose of physic, setting up excessive purging; and from retention of the placenta or after-birth in mares after foaling. With reference to the latter point, the after-birth in a mare should not be allowed to remain more than six hours.

In all cases of laminitis, the shoes should be removed immediately, and the feet put into cold-water bran poultices and kept constantly wet with cold water. The animals should be put into a loose box and frequently moved about.

The Diseases of the Feet are many, and in all cases of lameness examine the foot, even if certain that the leg is broken.

Simple Pricks or Punctures may be caused by picking up

nails on the road, or by bad shoeing. If not promptly attended they may lead to bad results, and even produce *Lock-jaw*. Remove the shoe, search the foot, and put on cold-water poultices; give the horse rest.

Corns are generally found on the inner corner of the foot, between the bar and the crust; hunters are most subject to them, on account of their being shod with short shoes.

The corn is caused by a bruise—an infiltration of blood into the horny substance. Sometimes they are very troublesome, and produce a great deal of lameness. Remove the pressure of the shoe, and poultice if necessary.

Seedy Toe is a crumbling of the horn into small particles resembling sawdust. It is due to some injury which prevents the proper secretion of the horn. Lameness may or may not result, but the complaint requires long and patient treatment.

Sandcrack.—Some breeds are predisposed to this. It is a forcible separation of the horny fibres, forming a fissure at the top of the hoof, at times extending to the bottom, found chiefly in perpendicular and brittle feet, and in many cases causing great lameness. When inflammation is present, reduce it by cold applications. It is needless to say that rest is required. This affection is looked upon as indicating unsoundness.

Quittor is due to sinuses in the foot with one or more fistulous openings, and is caused by some injury. It is chiefly found in pit and railway horses, and, being of a somewhat difficult nature to deal with, requires the attention of a qualified practitioner.

False Quarter is due to treads or injury to the coronary frog-band, one portion of horn over-growing another. This must be carefully looked for in examination as to soundness.

Canker is a fungoid disease of a very unpleasant and formidable character, and very difficult to treat. It is generally caused by the animals being kept in filthy boxes.

Thrush is a fœtid discharge from the cleft of the frog, generally arising from want of exercise and proper sanitation. Washing two or three times a week with salt and water has a salutary effect.

Fouls in the feet of cattle are caused by the animals being housed in filthy, wet boxes. The best treatment is to wash well with cold water, and apply cold-water bran poultices made up with a small quantity of carbolic acid (not more than one tablespoonful) to each poultice. The pulling of a rough rope through the cleft of the foot, and the application of butyr of antimony is to be strongly condemned.

Foot-rot in sheep is somewhat analogous to the last-named. It is mostly found in well-bred sheep, pasturing on soft, luxuriant

grass and too heavily fed with artificial food. The feet require to be attended to twice a week, paring the overgrowths where necessary and dressing with some antiseptic. The sheep, if possible, should be put on a gravelly fallow field for a few hours each day.

Navicular Disease, or *Groggy Horse.*—This disease is due to inflammation and ulceration of the navicular bone, implicating the tendon as it passes over this bone to be inserted in the floor of the coffin bone. It is of hereditary character and found in the fore-feet, more particularly of half-bred horses with upright pasterns. Animals doing little work and standing in the stables most of their time, are very subject to it. The disease is recognized by the animal going on its toe when first leaving the stable, and, when at rest, pointing the foot. The best preventive is daily exercise or putting into a loose box. Cold-water swabs to the feet when the horse is at rest are very useful. Owing to the continued irritation going on in the foot there is an extra growth of horn in these cases, therefore frequent shoeing, shortening of the toes, and thinning of the soles is highly necessary.

The Muscular System.

Muscles, like all other portions of the body, are subject to disease and injury. The most frequent troubles are caused by *Wounds* of various kinds.

(1) Incised wounds—clean cut with a sharp instrument.

(2) Bruised wounds—caused by force.

(3) Lacerated wounds—torn asunder by force.

(4) Punctured wounds—from thorns and sharp-pointed instruments. These are of dangerous character and require prompt attention.

(5) Gunshot wounds—balls, bullets, etc.

(6) Poisoned wounds.

Any of the foregoing wounds may heal by first intention or may take on bad ways and produce abscesses, tumours, gangrene or sloughing, septicæmia or blood-poisoning, pyæmia or abscess-forming, all over the body, as seen in bastard strangles.

The local treatment is first to arrest the hæmorrhage by tying the artery or vein. Arterial blood comes from a wound in spurts, and is bright scarlet in colour; to stop this, a ligature should be tied above the wound with pressure on the vessel. Venous blood is of a dark red colour, and flows in a continued stream which may be arrested with a pad of tow and a bandage applied below and on the wound. The next operation is to draw the lips of the wound together with stitches or sutures. This is

done with a suitable needle and silk, thread, cord, catgut, or silver wire. The part is covered over with flexible collodion to keep the air from the wound, or, where practicable, by cold-water bandages, which must be kept damp until there is a healthy discharge from the wound.

Bruised or Contused Wounds are caused by extensive injuries; kicks, blows. Where the wound has an external opening in the upper part of the injury close attention is required, as these cases are most liable to take on the form of septicæmia. The great object is to keep the inflammation within bounds, and encourage its reparative action and the formation of good healthy matter, or pus, for which purpose nothing is better than cold-water applications.

Lacerated Punctured Wounds have also to be treated in a somewhat similar manner.

Gunshot Wounds.—Remove the ball or bullet when practicable, and treat as for bruised wounds.

Poisoned Wounds are happily rare, except in cases where cattle and sheep having wounds in their skins are poisoned by washing or dipping with arsenical mixtures. This shows how necessary it is to examine the skin of these animals before submitting them to the action of poisonous preparations.

Muscles, at times, become lacerated without an external wound, as in shoulder-slip in young horses when first put to the plough. The muscles of the back and quarter also suffer from falls and injuries. At first the parts are slightly swollen, then they begin to waste away, and long rest, with a run at grass, is required for their recovery.

From accidents of this kind we sometimes find large quantities of clotted blood, owing to injury to a vessel. This may form either a tumour or an abscess, and requires special treatment to get a favourable and satisfactory result. For instance, **Poll-evil** is an injury to the poll, or part between the ears, caused by a blow or too heavy a head-stall. This is a rather formidable complaint, and ought to be put into the hands of a qualified practitioner.

Fistulous Withers are of a similar nature, and require prompt attention. They should on no account be tampered with by an amateur.

The Elbow Joint is sometimes bruised by kicks or improper shoeing, the horse bruising the point of the joint by lying on the heel of the shoe. The injury must be treated with hot or cold fomentations, and a pad put on the fetlock to prevent any further damage.

Broken Knees must be treated as recommended under bruised

wounds. Cleanse the parts well, dress with carbolized oils, put on cold-water bandages, which are to be kept moist until healthy action is established, and finally dress with a little caustic lotion. In all cases tie the head up with a double-shanked halter to prevent the animal lying down.

Wind-galls, or distension of the synovial bursæ, are seen at the knee, fetlocks, and more particularly at the hock-joint, forming **Bog Spavin** and **Through-pin.** The two latter are mostly seen in Clydesdale horses, and are in a great measure due to over-feeding. They can also be produced by over-working young horses. The treatment is rest, indiarubber bandages, blistering, and firing.

Sprains of the back tendons are caused by over-exertion. Immediately these are observed, the animal ought to be rested and put under treatment, as they are almost as bad to treat as a broken leg. On no account should the animal be worked till fully recovered.

Some classes of cart-horses are prone to a hereditary disease called **Luxation of the Patella.** The stifle joint becomes distended with synovial fluid; the cup, or patella, slips partly off to the outside with a cracking noise. Animals of this class should never be bred from, nor put on hilly pastures.

Repeated blistering and long turned-up-toed shoes are recommended.

The patella at times becomes dislocated by the animal jumping up suddenly from a recumbent position. The leg is held in a very peculiar position, being extended backwards, with the point of the toe resting on the ground, and the sole of the foot turned upwards. This must have immediate attention, and be reduced as quickly as possible.

Curb is a sprain of the calcaneo-cuboid ligament, and may be caused by over-exertion or a blow from a kicking-horse. When it arises suddenly, the animal shows a good deal of pain and lameness, the parts are swollen, and the skin tender. These must be reduced by cold applications, blistering, and, if necessary, fire. Some hocks have naturally a curby formation; but it is only due to the ridge on the outside of the joint extending too far behind, and the large metatarsal bone being set too far back, with a short os calcis. These joints are more liable to take on curb than those that are well developed.

Capped Hock may be caused by the horse kicking in the stable or against any hard substance. The point of the hock is distended and, when freshly done, is very painful. If merely an effusion under the skin, it may be removed by suitable means. Should it extend to the synovial bursa underneath, it is of more

consequence and difficult to reduce, while, if not properly treated, an enlargement is left which is a great eyesore. Sometimes it is caused by the animal scraping all its litter to one side, and lying on the hard floor of the stall. In these cases, moss litter or sawdust ought to be used for bedding.

Reduce the inflammation by cold applications and mild stimulating linaments; but never be in too great a hurry to apply a blister.

Sesamoiditis.—This is a sprain of the tendon passing over the back part of the fetlock joint. The animal goes stiff and sore, stands straight up on the pastern-joint, with slight knuckling-over. The parts are found on examination to be slightly swollen, and painful to the touch.

Rest, with cold-water bandages, until the inflammation is reduced. Blister or fire afterwards, if necessary.

In connection with the hind leg, a complaint is known which is frequently seen on a Monday morning, and called **Weed**, or **Lymphangitis.** It is really inflammation of the absorbent vessels running up the inside of the hind limbs. It sometimes occurs in the fore limbs, though very rarely. Some breeds seem to be predisposed to it. It is mostly seen in cart-horses with gummy legs. Sometimes it commences with a shivering fit, the animal has great pain, and can scarcely stir the limb, the perspiration rolls off the body, breathing quick, nostrils dilated, pulse full and strong, inside of thigh painful to the touch, the absorbent vessel very much distended, and like a great cord running up the thigh. In other cases the disease comes on slowly and quietly, and the acute symptoms are not observed. When discovered, the treatment should be as follows: A soft meadow-hay bandage is made, and rolled round the limb from the bottom to the top. Down this, pailfuls of cold water are poured every two hours; and fine linseed oil, 20 ozs., should be given, together with nitrate of potash water to drink. When the limb begins to swell, the pain and lameness generally pass off, and the swelling is then reduced by gentle exercise, with tonic-diuretic medicine.

The Respiratory Organs.

These are the nostrils, larynx, trachea or windpipe, bronchial tubes, and lungs. The ever-changing state of the atmosphere, with the various conditions under which domestic animals are placed, renders these organs very liable to derangements.

The Nose is subject to tumours, bot-worms, injuries, etc., and also to nasal discharge from a common cold—**Catarrh.** This is frequently seen in the early spring months, and, however simple

it may be, should never be neglected, as it might terminate in congestion or inflammation of the lungs, and death, or in a chronic discharge from the nostrils called **Nasal Gleet.**

When observed, the animal should be laid off work at once, and put into a well-ventilated box with suitable clothing; sloppy food (green, if it can be obtained), carrots and potatoes; and nothing is better than well-boiled, sound barley, with a little nitred water to drink.

Occasionally abscesses form in the sinuses of the head in connection with the nasal chambers. This might be due to an injury, neglected cold, or diseased teeth. In these cases we have a thick discharge, sometimes of a very fœtid nature, from the nostrils. For relief of this, the operation called trephining has to be resorted to. The fearful malady called **Glanders** is, happily, very rarely seen in country practice, and not so frequently in towns as it was some years ago. It is a very contagious disease, both to other animals and to the human subject; and in all cases of suspicion the aid of the qualified veterinary practitioner must be resorted to, and the animal destroyed at once. The ulcerations on the lining membrane of the nose, and also the discharge, have peculiar characteristics.

Laryngitis, or *Inflammation of the Larynx*, is due to sudden chills, exposure and injuries. The throat is sore, the animal afraid to cough, and, in drinking water, a portion comes back through the nostrils. The throat is painful to the touch, nose poked out, and sometimes a roaring is made in breathing. Give good nursing as recommended under "Catarrh." Constitutional disturbance, when present, must be attended to. Give nitrate-water to drink, and apply stimulating lotions to the throat. The bowels must have attention, and be regulated with the diet if possible. Drenches or draughts ought never to be given, as they are very dangerous. This complaint should never be neglected, as it may terminate in that incurable disease called **Roaring**, which is the result of inflammation of the larynx, from injury or other causes, and a wasting of the muscles on the left side. In some cases the animals become so oppressed that they are like to be suffocated. Tracheotomy has then to be resorted to. This is a simple operation, performed by cutting into the windpipe and inserting a tube. There are several modified forms of roaring, such as whistling, highblowing, and wheezing. These all must be looked upon with suspicion, as they usually terminate in roaring. This affection is considered by many as hereditary, and, we need scarcely say, is an unsoundness. Another cause is **Strangles.** This is a common complaint in young horses, two or three years old, and is of two kinds—simple and complicated. At times it is

considered to be associated with the casting of teeth — see remarks on "Teeth,"—and is known by abscesses forming at the angle of and behind the jaw. In the simple form, good nursing and proper dieting may be all that is required. The simple form, if neglected, may terminate in the **Bastard Strangles,** in which abscesses form in different parts of the body. They sometimes result in pyæmia, or blood-poisoning. Stock-owners should on no account neglect these cases, however simple. A sudden chill or a common cold may bring on this complaint; therefore horses with relaxed systems ought never to be exposed to cold east winds or heavy work. **Congestion of the Lungs** may be the result, and death take place in four or five hours; or it may end in **Bronchitis,** inflammation of the lining membrane of the bronchial tubes, causing great debility in a short time. This is owing to the lining membranes of the bronchial tubes becoming thickened, and preventing the proper oxidation of the blood. Dark carbonized blood is accordingly sent through the system, and acts on the nerve centres, producing general and extensive prostration, or the case may end in **Inflammation of the Lungs,** or **Pleurisy.** These are all formidable complaints, and should not be tinkered with by amateurs. The animal should at once be put under the treatment recommended for common cold, and a medical practitioner sent for without delay.

Asthma, or *Broken Wind.*—This is a rupture of the air-vessels of the lungs, and not amenable to treatment. Cases are met with, however, where all the symptoms of asthma are depicted, and which may be due to spasm of the small muscles of the lesser bronchial tubes. By proper and judicious treatment this can be relieved. Although a disease of the respiratory system, the writer is of opinion that it is in a great measure due to injudicious feeding and driving. The complaint is not so rife as it was some years ago.

Cattle suffer from a great many complaints of the respiratory organs, similar to the horse. The most formidable of these is **Pleuro-pneumonia,** which is a febrile contagious disease of the lungs. Being under Government regulations, it is against the laws to put any under treatment.

There is a simple form of pleuro-pneumonia among cattle, the symptoms of which are analogous to those of the contagious; which are falling off in milk, hurried breathing, with peculiar grunt, nose poked out, ribs flat, standing in anxious position, with a peculiar tight dry cough. Animals should be isolated at once, and medical attendance sent for.

Another disease affecting the chest is that of **Tuberculosis,**

Clyers, or Piners. This disease is of hereditary character, found principally among fine-bred cattle. It is spread more by the male than the female, for the simple reason that a diseased male animal has from one hundred to two hundred chances to the female's four or five of transmitting the complaint. Therefore animals, no matter how well-bred or how costly, when suffering from this complaint ought never to be used for stock purposes. It is said by many to be contagious; in certain cases it may be so, where a diseased animal comes in contact with another of a fine delicate organization with a hereditary tendency to the malady.

Strange to say, like consumption in the human subject, it most frequently establishes its action when the animals are coming to puberty. It is said to be due to a bacillus; but how it lies latent for such a time in the system is a mystery. Although a large quantity of the flesh of tubercular animals has been, and is being, consumed by the human subject, there is no case on record that can be traced as to the tubercular meat being the cause of death.

The milk of tubercular animals should not be used for human consumption, as it has been said that cases of consumption in young children has been traced to its use (?).

Therefore, if the meat and the milk be so dangerous for human beings as some people say, special regulations should be made by the Government for their purchase and destruction. These carcases should not be buried, but burned in a furnace.

Hoose, or *Husk,* in calves is due to little white worms, called *Filaria bronchii.* It is caused by putting young calves, from four to six months old, out to graze on cold wet lands in the autumn, more particularly during wet weather, and leaving them out after sundown. Numbers of animals are yearly destroyed by this complaint, which, in the writer's opinion, is very easily prevented, but bad to cure. Prevention: never turn the young animals out until over twelve months old; keep them indoors during wet weather; dress the pastures with crushed rock-salt in September and March, at the rate of five to seven hundredweights per acre. The treatment is, mild doses of turpentine and oil, or fumigations with chlorine or sulphurous fumes. Maintain the strength with well-boiled linseed jelly and milk; but whenever the disease exists it is entirely the breeder's fault.

Young calves at times, even when indoors, may contract a **Bronchitic Cough.** This is sometimes called, and mistaken for, hoose, but is quite another complaint. It is simply inflammation of the bronchial tubes; and no parasites are found, though it is frequently associated with that troublesome complaint called white scour. Good nursing and sanitation are strongly recommended.

Associated with chest affections we have **Distemper** in dogs, the treatment for which is good nursing, and small doses of hyposulphite of soda and carbonate of ammonia, with warm, comfortable beds.

The Circulatory System.

Diseases of the heart are, happily, rare in the horse, the principal one being that of **Hypertrophy**, or enlargement of the heart, with intermittent pulse. Animals suffering from this can do slow work for a long time, but ought never to be excited. They seem to suffer from shortness of breath, best seen when bringing a load uphill. The patient then appears oppressed, and has frequent rests. Scarcely necessary to say, quiet easy work and judicious feeding are required.

Pericarditis—inflammation of the sac covering the heart. This organ is more or less affected in bad cases of influenza, or pinkeye; great debility and prostration result, and the disease at times runs its course very quickly. Over-fed animals may suffer from **Fatty Degeneration** of the heart. This class of horses also has a tendency to *fibrous clots* forming in the auricles and ventricles, more particularly in fat stallions. These fibrous deposits are increased by bleeding, therefore fat horses ought only to be bled with great caution. The farrier, in the old days, used to call this disease "grease at the heart," which he himself had produced by frequent bleeding. Associated with chronic heart disease we have swelling of the legs and other dropsical effusions, with irregular pulse and jerky flow of blood in the neck vein.

Cattle suffer more from heart disease than horses, but it is more frequently of a *traumatic* character; needles, wire, sharp nails, and other foreign bodies finding their way from the second stomach, through the diaphragm, to the heart. The animal often does not appear to be ailing anything until it is found dead, and the post-mortem reveals a foreign body sticking in the heart.

The writer has observed, for many years past, chronic pericarditis follow the retention of the after-birth. When cattle suffer from heart affections the animal appears stiff, with nose poking out, head hanging rather low, and, although feeding, does not put on flesh, while, if a milker, the secretion is more or less suspended. The best symptom, however, is the enlargement of the jugular vein on each side of the neck, the vessel being often distended to a diameter of one and a half to two inches. Dropsical swellings are also seen on the under jaw, under side of neck, and brisket. As there is no remedy, the animal must be slaughtered.

Young calves, under twelve months old, suffer from congestion of this organ. The cause is overfeeding with too much nitrogenous food, more particularly decorticated cotton cake, which ought never to be given to animals under one year old. This complaint usually commences with a dry, husky cough.

The blood-vessels are subject to dilatations in certain diseases, especially that of thrombi, or clots, plugging up the vessel. When this occurs in the extremities, the animal falls suddenly lame, and is scarcely able to move the limb, and then only with great pain, while perspiration rolls off the body. This requires long rest and patient treatment. The attacks come on suddenly, like paralysis.

The diseases of the blood are many, as all the epidemics are more or less affections of the blood in the first instance, owing to the entrance of germs, microbes, and bacteria. When these get a footing into the system they rapidly multiply.

It is said that the white corpuscles, or leucocytes, have the power of destroying these microbes when first taken into the blood. At times, however, they will not attack the disease-producing germ. The latter then gets master of the system, and the malady becomes established.

Black Quarter, or *Quarter Ill*, is not so rife as it was formerly. The improvement is possibly due to the better drainage of the land, and a more systematic mode of feeding. It usually attacks the best furnished and finest looking animals, and is known by a crackling and swelling of the part affected, due to decomposition of the blood in this part with evolution of gas. It attacks animals from four months to three years old, fifteen to sixteen months being the most critical age. There are many modes of prevention put forth. The writer recommends setoning the dewlap of the young animals at the back end of the year. Never, in all his practice, has he seen a stirk die from black quarter that had been setoned. Some localities are more prone to it than others. These lands should have a good dressing of salt, as it is the cheapest and most effective germicide in nature.

Rinderpest, being an imported disease, affecting cattle in a very virulent manner, but which this country has been free from for some time, has, it is to be hoped, been seen the last of by the British farmer.

Foot and Mouth Disease is an epizoötic, infectious, as well as contagious, febrile complaint, of a vesicular character, affecting the tongue, cheeks, digits, and udder of cattle, sheep, pigs, goats, and even poultry. The symptoms are smacking of the lips, flow of saliva from the mouth, lameness, and lifting up the leg as if the animal was walking on red-hot bars. Being a disease under the Contagious Animals Act, treatment is not allowed; but chlorate

of potash, in half-ounce doses night and morning, is the very best specific.

Anthrax, or *Splenic Apoplexy*, is a disease of the blood, which will be referred to under "Digestive Organs."

Azoturia in horses.—Although an affection of the blood, it is more of a dietetic character, and found mostly in horses having easy berths—well fed, with little work. It is generally observed at the commencement of a journey, say of quarter-mile, after the horse has been three or four days in the stable without exercise. The animal comes out of the stall full of life; but does not go far until it seems as if wanting to stop, and the hind limbs appear to stiffen. On urging the animal forward, he begins to tremble and perspire, and finally stops. He is got back to the stable with great difficulty. The urine is of a dark coffee colour, the loins are arched, the muscles hard, belly clicked up, breathing hurried, and head hanging. If a mare, she pains as if in the act of foaling, and, in straining, ejects a quantity of dark-coloured fluid. When the animal gets down, the case usually terminates very unsatisfactorily. The disorder appears to be due to an overloaded state of the system, and no doubt it is so, seeing it is only idle well-fed horses that are subject to the attacks. Again, nature shows it to be an over-burdened state of the system, by the excessive perspiration that bedews the body, and the solid particles ejected by the kidneys. The horses also take a long time to purge. If there be one complaint more than another that bleeding will relieve almost instantly, it is azoturia. The writer has seen, over and over again, cases in which, six hours after bleeding, the patients seemed to be ailing nothing. Cases which have not been bled have either ended in death or have taken weeks for recovery.

Influenza, or *Pinkeye*, may be looked upon as a disease of the blood, affecting sometimes the respiratory organs, at other times the digestive organs, urinary organs, or limbs. It must be treated according to the symptoms presented. Being of a debilitating character, stimulating treatment is generally the most successful. Nothing beats good nursing, a well-aired loose box, clothing the legs, chlorate of potash water to drink, with bran-tea and treacle. Purgatives must not on any account be given, except, if required, ten ounces raw linseed oil at the onset, and repeated in ten to twelve hours if necessary. As a sequel to this complaint, we have—

Purpura Hæmorrhagica.—This is known by swelling of the head and limbs, and purple patches lining the nostrils. Good nursing, with suitable food, and half-ounce dozes of chlorate of potash in drinking water are the chief remedies. Eggs beaten up in milk, if the animal will drink, are of great service.

Urticaria, or *Nettle-rash*, is frequently seen in the horse in the spring and autumn. It is caused by the animal getting unaccustomed food into the stomach, such as a feed of new oats or grass for the first time. The affection appears suddenly, and all the body becomes covered with large raised-up blotches. The treatment is simple: 1 to 2 oz. carbonate of soda given in a pint of water with 1 gill whiskey, and followed up with bran mashes and salt. Cattle, in early spring months, are subject to a somewhat similar complaint, known in Cumberland as **Blains**. The head, neck, eyes, and ears are swollen, the skin feels thickened all over the body, the parts around and under the tail are also swollen. Formerly bleeding was said to be the only cure; but carbonate of soda and whiskey, as given for nettle-rash in horse, or 1 pint raw linseed oil with 1 wine-glassful of turpentine, generally answers well for cattle.

The Digestive Organs.

These are the lips, mouth, cheeks, tongue, teeth, and other accessories, such as the salivary glands, the gullet or œsophagus, stomach, and the small and large intestines, the total capacity of which is estimated at about thirty gallons.

The accessory organs of digestion are the liver, spleen, pancreas, portal vein, glands, etc.

The digestive organs may be looked upon as the most important in the system, and, being exposed as it were to such a variety of changes in the food and treatment, they are most subject to derangement, injury, and disease.

The Tongue suffers from injury caused by foreign bodies, as thorns, nails, fractured teeth, etc.; hardening or induration; damage by the administration of balls; and the rough usage of ignorant carters or grooms. Occasionally it becomes paralyzed and injured to such an extent at the tip that gangrene sets in, and portions have to be cut off. In cattle the tongue is also subject to injury from similar causes, and also to induration and a disease called **Actinomycosis** (said to be a cancer). In all these cases the animal falls off its food, loses belly, becomes emaciated, and there is a greater or less flow of saliva from its mouth. Every care must be taken in having the mouth examined and the offending cause removed. Young calves suffer from a carbuncular disease, which affects not only the tongue, but also the sides of the cheek. It is generally found in fine-bred cattle from six weeks to two months old. It requires special medical treatment, and should not be neglected.

It is impossible, in a report like this, to enumerate the various injuries and diseases that the mouth and tongue are liable to, but sufficient has been said to cause proper examination.

We next have obstruction of the gullet, as in choking. This is very rare in the horse, and could in great measure be avoided if the stableman were sufficiently careful in spreading the food along the floor of the manger. When choking takes place, the symptoms are very peculiar: the horse pokes its nose out, convexes the neck on the under side, pulls its ears towards the shoulders, nearly touches the ground with his knees, and utters peculiar sounds. Find out what is the cause of the obstruction; if from corn or food, remove as much as possible by passing the hand to the back of the mouth, and washing out with fine thin sifted gruel or warm water. If the cause be a hard foreign body, it must be left in the hands of a qualified man.

Fine-bred cattle are subject to abscesses forming in the back of the throat or pharynx. The animal pokes its nose out, and has great difficulty in breathing. Occasionally the abscess can be felt from the outside. A good smart iodine blister should be applied to hurry on the suppuration, and, when sufficiently ripe, the abscess must be opened by passing the hand to the back part of the throat with a suitable knife. Sometimes the disease gets so troublesome that tracheotomy has to be performed to prevent the animal suffocating. In other cases we find large tumours or polypi forming in the back of the throat. They have to be removed by an operation. These produce the same symptoms as the abscess. Cattle are very liable to choke with turnips and potatoes. If possible, the obstruction, when in the upper part of the gullet, should be removed by working the hand into the passage, or by pressing into the stomach with the probang or turnip-rope. The latter operation must be done with great care, as the gullet or œsophagus has in many cases been ruptured by injudicious passing of the rope. On no occasion should fluids, oils, etc., be given, as they only oppress the patient. In these choking cases the animal swells up on the left side by the evolution of gas from food in the stomach. This sometimes takes place to such an extent that there is danger of the patient dying a mechanical death, from the pressure of the gas in the stomach and bowels upon the heart and lungs. If medical aid be not at hand, there need be no hesitation in taking a sharp knife and stabbing through the side into the stomach. The point at which this should be done is at the most distended part, viz. between the last rib and the hook bone on the left side. The knife is then turned crossways in the wound, to allow the gas to escape. In some instances, after removing the pressure of the gas, the turnip

or potato sticking in the gullet will drop into the stomach without any further trouble.

The Œsophagus, or *Gullet*, is subject to dilatation, stricture, ulceration, as well as various injuries.

The Stomach of the horse is comparatively small. From injudicious feeding, or the animal gorging itself on grass or corn, it is liable to derangement, distension, and disease. By the fermentation of food, and consequent evolution of gases, it is often ruptured. In some cases of distension the horse stands persistently still, hangs his head, and is much swollen on both sides. If the derangement be due to an over feed of badly boiled wheat, barley, or Indian corn, 2 oz. of carbonate of soda given in 1 pint of water with 2 oz. aromatic spirits of ammonia, or ½ pint whisky, may give instant relief. Instead of this, we may give 4 oz. hyposulphite of soda, 30 drops best carbolic acid, 2 oz. essence of ginger in 1 pint of water. At other times we have great abdominal pain, as **Colic**: the horse lies down, gets up, rolls about, paws the ground with his fore feet as if in great pain, and turns his head to his side. In addition to the previous treatment, laudanum or chloral hydrate would have to be administered, or the gas let off by puncturing the abdomen; but this should only be attempted by a qualified practitioner.

The **Horse Bot** (*Gastrophilus Equii*) has its winter habitat in the cuticular or front portion of the horse's stomach. Where the bots are attached, the walls of the stomach are thickened; and, from irritation caused by the development of the larvæ, the animals, in many cases, lose flesh. If their presence be suspected, occasional small dozes of turpentine and linseed oil should be administered.

The stomach is also at times infested with the large white earth-worm. These are, however, more frequently found in the small intestines, causing loss of flesh, ragged coat, and occasional diarrhœa. When suspected, turpentine and linseed oil is the best remedy, with a little salt every night in the food.

The stomach is subject to inflammation (*Gastritis*), generally due to irritating substances. When acute, the horse exhibits great pain by rolling about. Sedative medicines must be administered, and blankets or flannels, wrung out of hot water, rolled round the body. The stomach may become relaxed or suffer from acute and chronic indigestion, for which vegetable, alkaline, and mineral tonics are to be prescribed. The animal should be tempted with different kinds of food, and nothing is better than chopped fresh thorn shoots or gorse, mixed with the corn.

The small intestines are liable to various diseases and

disorders, such as spasms, inflammation, intussusception, strangulation, twist, knot, gut-tie, rupture, worms, tumours, etc. All commence more or less with colicky pains, and require the experienced eye of a practitioner to detect. They are often very formidable and dangerous maladies. At the beginning, when the pain is severe, 2 to 4 oz. laudanum with 2 oz. spirits of nitre may be given in 1 pint of linseed oil, and half the quantity repeated in 30 minutes if necessary. Should the pain be due to simple spasm (colic) of the bowels, the animal will soon get relief from the above treatment. Warm-water injections may be administered, for which purpose nothing beats the funnel-shaped enema (Fig. 32).

FIG. 32.

If much flatulency be present it is best to give a tobacco enema, as follows: 8 inches twist tobacco are unrolled and steeped in 1 quart boiling water; and, when new-milk warm, the decoction is given as an injection.

In **Twist**, or *Knot*, of the bowels, from long experience the writer is of opinion that the lesion is caused entirely by the spasmodic contractions of the circular and longitudinal coats of the intestines, and not by the animal rolling.

The LARGE INTESTINES of the horse are subject to impaction or constipation, spasms (spasmodic colic), inflammation, congestion of the mucous coats, concretions or dust balls, worms of various kinds, paralysis, distension with gas (flatulent colic), and rupture.

The symptoms resemble those named under the small intestines, and similar treatment is to be adopted at the first onset.

In **Impaction**, or constipation, of the large intestines, the horse does not seem to suffer much acute pain, occasionally having three or four hours' interval of relief before the colicky pains return. These cases require to be relieved by judicious administrations of purgative medicines followed by enemas.

In derangement of the large intestines the animal is inclined to roll over on his back, or sit on his haunches like a dog. Abscesses are occasionally found in the rectum from injuries, etc., and sometimes we have eversion of this portion of the intestines. It is also at times lacerated during the act of foaling in the mare.

Horses, as a rule, very seldom suffer from acute diarrhœa, except when an overdose of purgative medicine has been administered. Acute diarrhœa in the horse is usually fatal, or produces laminitis (inflammation of the feet). Small doses of chlorodyne might be given, and a little water with well-boiled oatmeal gruel and carbonate of soda to drink. If chronic, and found to be due to teething fever, the mouth should be examined and the cause removed.

If the complaint is produced by worms, as is frequently seen in young horses in spring, after pasturing on rough wet pastures in autumn, small doses of oil and turpentine, with salt in the food, can be recommended.

Intestinal Hernia, or *Displacement of the Intestines*, takes place internally. The symptoms are somewhat similar to twist of the bowels. The complaint is difficult to diagnose, and terminates fatally.

Young foals are frequently the subject of scrotal or umbilical hernia. The former, in nine cases out of ten, disappears before the animal reaches the age of one year. It ought never to be interfered with until after that age, unless some fæces get into the sac and cause the animal great pain. Umbilical and ventral hernia can be successfully treated with properly arranged truss and bandage, or radically cured by an operation.

Stomachs of Cattle.

Unlike the horse, derangements of the digestive organs of cattle and sheep generally take place in the stomachs, and no matter how slight a disorder of any of the other organs of the body, the functions of the stomachs are more or less suspended, and they require attention and treatment as well as the original complaint.

The first stomach, or paunch, is subject to many disorders, produced by such causes as drinking an excess of ice-cold water, frosty turnips, impaction with aftermath, foreign bodies such as nails, bones, stones, leather, hair-balls, etc., and also by abscesses, tubercular tumours, etc.

When the animal is distended with gas, which is the principal symptom of nearly all the foregoing complaints, endeavour to trace the cause, and treat accordingly. Two ounces of carbonate of soda, dissolved in a pint of water, with half a pint of whiskey may be given with advantage, or one pint of oil and one wine-glassful of turpentine. If dangerously swollen, let off the gas, as recommended under "Choking."

The second stomach generally contains a quantity of sand,

nails, wire, stones, etc., and may be looked upon as a sort of sifting agent. It is subject to inflammation and injuries from irritating substances.

The third stomach—or maniplies, owing to its numerous leaves—is in hot weather subject to gorging. The leaves or folds then become paralysed from the continued pressure of the food, which becomes hard and dry, and produces what is called **Fardel bound.** Since the introduction of artificial cakes for the feeding of cattle, this complaint is not so frequent as in former years. Saline purgatives, combined with oil and stimulants, answer best. In all derangements of the stomachs of cattle producing indigestion the animal has a peculiar grunt, which is heard more when the spine is pressed just behind the shoulders. The back is raised up, and the disease formerly went under the name of "heart-fellon."

The fourth, or true digestive stomach, is the largest in the calf, and most subject to inflammation and disorder.

Poisons, both vegetable and mineral, rarely establish their action until they enter this organ. The writer has known several cases of arsenical poisoning, where the arsenic remained in the three first stomachs for from four to eight days before it reached the fourth and established its poisonous action.

In hot dry weather, more particularly in June, when certain grasses, ryegrass especially, are on the point of seeding, we have a complaint amongst cattle called **Stomach Staggers.** This malady is rarely, if ever, seen in wet weather, and, in the writer's opinion, the hot, dry times cause the plants to seed prematurely. At the point of seeding, there appears to be some narcotic principle produced, or chemical change undergone, which acts on the digestive organs of cattle, and, by reflex action, on the brain. The first symptoms are a sudden decrease in the flow of milk; coat staring as if singed; breathing slow and heavy; eye of a grassy green hue; occasional twitching of the muscles of the face and trembling of the extremities; knuckling on the hind fetlocks; ribs flat. These symptoms may last three or four days, and then the animal commences to press its head against the wall or fence. At this stage the butcher's aid is of more value than the vet.'s. At the commencement give a quart of warmed ale, 1 oz. mustard, 2 lbs. treacle, and 1 pint linseed oil; to be repeated every eight hours. On no account should salts be administered; they act as a poison. Linseed jelly and milk, with bran or hay tea, may be given to the animal to drink.

The INTESTINES of cattle are not so liable to derangement as those of the horse. They occasionally suffer from spasm or colic, and inflammation, but seem to be more prone to the affection called **Gut-tie.** This is most frequently seen in bullocks. When the

animal appears to be suffering pain, small doses of chlorodyne, from ½ to 1 oz., combined with 10 to 15 ozs. of raw linseed oil, may be given with advantage every six hours. The most common complaint affecting the digestive organs of cattle, particularly young ones, is that of **Diarrhœa.** This can be brought on by an overdose of frosted turnips or potatoes, etc.; but young cattle, from one year nine months, to two years six months, in many localities seem to suffer to an alarming extent from this complaint.

In some instances it may be due to the animal casting the shells or crowns of the molar teeth, producing teething fever. In other cases it arises from the young stock having been turned out at the back end of the previous year, more particularly if the autumn has been very wet. A quantity of worms and the ova of various parasites are then taken into the stomachs with the wet grasses, and establish themselves there with grave results during the following spring.

Flukes in the liver are a very common cause; as a prevention against these, the animals should not be put out to grass in the autumn, or even in a wet summer. Keep them indoors, and give them a little crushed oats and cake, with a little salt. If this plan were more generally adopted, diarrhœa in young stirks would soon be a thing of the past.

If the teeth are supposed to be the offending agents, have the mouth examined and the shells removed. In many cases we have this diarrhœa originating from tubercular disease of the liver, mesentery, and bowels. These cases are generally not worth treating. For symptoms, see page 252, under "Teething."

Dysentery, or *Bloody Flux.* At one time this was a very common complaint in cattle, and considered to be due to the rough coarse-grained grass grown on undrained lands. It is now of rare occurrence, but when present it ought never to be in the least neglected. When the extensive diarrhœa is mixed with blood, it is very difficult to treat, and generally terminates fatally.

Peritonitis.—Inflammation of the lining membrane of the inside walls of the belly. This membrane is also reflected over the outside of the intestines. It is a very formidable complaint. In the horse, it creeps on very insidiously, and the animal is at the point of death in many instances, before observed. It is more common in cattle, and due to many causes, such as difficult parturition, injuries, sudden chills, etc.

The treatment should be energetic, and put into the hands of a qualified practitioner.

Dropsy of the Belly may arise from the foregoing malady, and also from diseased liver in which the bloodvessels are blocked up, and from other causes.

The LIVER is the largest organ of the body in the young calf, and in the adult animal is so situated that it is subject to derangements and diseases from the various modes of feeding, hot climates, weather, and situations.

The most common affection is that of—

Congestion and a sluggish state of the organ, producing yellows (jaundice). This yellowness of the visible mucous membranes and skin may also be due to many other causes, such as bile stones, tubercles, hydatids, flukes, etc.

Inflammation is not of common occurrence in horse, or cows.

Fatty degeneration, and fatty infiltration are more frequently met with, particularly in idle, well-fed horses.

The liver is also subject to rupture from falls in jumping.

In disorders of the liver we have general depression, languor, lameness in the off fore leg (more particularly in horses), fœtid breath, furrowed tongue, eyelids and lips yellow, and also yellow udders in cows.

Gall Stones are very rare both in horses and cattle. When present, they cause more or less colicky pains, and continue for several weeks, finally producing all the appearances of a man blind drunk.

SPLEEN, or *Milt*.—Little is known about the function of this body. Although an important organ, it can be done without, as we have record of its removal without much inconvenience to the patient. The writer's idea is that it is a receptacle for blood during the process of digestion.

When under disease, it produces very grave symptoms. In the horse we have a complaint called—

Lymphadenoma, in which peculiar tumours of a flaky pearly character form all through its substance. The symptoms are—staggering gait, mucous membrane covering the mouth and eyelid extremely pale, animal continues to feed well but loses flesh, and has to be supported on slings. It generally has a fatal termination.

Cattle also suffer from a disease of this organ called **Splenic Apoplexy**, or a variety of *Anthrax*, which runs its course, and terminates fatally in a few hours. Although a disease of the blood, the writer considers it more of a dietetic nature, having seen it produced from steeped brewer's grains allowed to stand till they had reached the acetous stage of fermentation. It is also produced by the hay bacillus, obtained from the fermentation of chopped hay and from mouldy cotton cakes, more particularly the undecorticated variety. He has also seen it arise on certain undrained lands. Although very fatal to other animals, such as dogs, cats, and poultry, that may have eaten the flesh or blood,

yet he considers it neither infectious nor contagious, having never known it to extend beyond the buildings in which it originated. Again, the disease was always traceable to some peculiarity of the feeding, and the writer thinks that it is analogous to an aggravated form of *Red Water*. This he has seen produced by a similar mode of feeding. In both cases the bladder contains dark coffee-coloured urine, but in splenic apoplexy dirty dark-coloured water is found in the abdominal cavity and intestinal canal, and the spleen is gorged with a thick dark bloody fluid, and much enlarged.

Red Water in cattle is now almost a thing of the past in many parts. It was found on undrained, sour, and mossy lands, and was due to the want of a proper quantity of alkaline matters in the food. Chloride of sodium—common salt—was the body most required in order to keep up the balance between the solid and fluid portions of the blood. Draining, where practicable, is the best preventive. The next is the dressing of the lands with from six to ten hundred-weights of rough crushed rock salt to the acre. Wherever this treatment has been adopted, the disease has entirely disappeared.

Braxy in sheep is a somewhat similar disease, and it could in great measure be prevented by giving the animals a change of food when first put on to turnips, such as cut hay, mashed oats, and bran, with a small amount of salt or uncut hay well saturated with salt and water.

Mesenteric Disease is most frequently found in well-bred short-horn cattle. Tumours or abscesses of various sizes form throughout the mesentery. The animals, although feeding, rapidly lose flesh, are hide-bound, have a dirty, yellow, scurfy skin, with diarrhœa. No good can be done, and the animals should be destroyed at once, and burned in a furnace.

Calves suffer very much from derangement of the fourth stomach, and more particularly so when only fed twice a day, with large quantities of milk. The juice secreted by this stomach is called "rennet," and is used to curdle milk in the manufacture of cheese. The first process of digestion is, therefore, the formation of the milk into a stiff, hard, curdy mass by this acid juice. If in excess, irritation and inflammation are set up, and nature tries to relieve herself with spontaneous diarrhœa, called **White Scour.** This complaint carries off hundreds of young calves yearly, and, once established, it runs its course. It is, no doubt, infectious, and due to the *Lactus bacillus*. Preventive measures should be adopted—(1) by the judicious feeding of the young animals four times a day for the first three or four weeks; (2) by giving no decorticated cotton cake to the mothers for three or four weeks before and after calving; (3) by cleansing out the

nursery boxes well not less than once a month, and washing the walls with lime-wash containing a small amount of carbolic acid. Where the disease does exist, the best treatment is to keep the milk twelve hours, take off the cream, and warm the milk in a water-bath to 88° or 90°, in which give one wine-glassful of lime-water night and morning.

The best preventive, however, is to put the mother and calf into a good large box and leave them. This is also the best means of preventing milk fever.

Hair-balls, at times found in the stomachs of young calves, are caused by giving unstrained milk and by the animals licking each other. These balls cause a great deal of derangement and swelling, with impaired appetite. Sometimes the patients recover, but when the swelling occurs twice or thrice a day make them into veal as soon as possible.

Young calves are also subject to diseases called **Joint Fellon** and **Navel Ill**. These can be regarded as the same complaint, of a septic character, and generally found in damp boxes. They are due to septic material getting into the system through the navel opening. As a preventive the writer strongly recommends tying the navel string with a piece of antiseptic cord immediately the animal is born. Young foals suffer from somewhat similar complaints, and should be treated in the same fashion. The diseases are frequently fatal, especially joint fellon, and should be looked to at once. Young foals, five or six hours after birth, ought to be carefully watched; and if found straining, warm-water enemas should be given by the rectum. For this purpose breeders of foals should always have a human enema pipe by them. Good sanitation, ventilation, and cleanliness should be the first object in view in rearing stock.

Dentition and Dental Diseases in Horses and Cattle.

Dentition.—*Horse.*—By the casting or shedding of the crowns of the temporary teeth, and their replacement by the permanent teeth, together with certain marks, the age, for a time, is indicated.

At birth the foal generally has the two central incisors, and three molars on each side, above and below, all of which are temporary. At six to eight weeks old he gets two lateral temporary incisors above and below; and from eight to ten months the corner incisors.

At *one year* the fourth molar (permanent) appears; and from two to two and a half years the fifth molar should be up. In many cases in cross-bred cart horses the fifth molar does not appear until from two and a half to three years.

At this age (rising three) he commences to cast the two central incisors, also the first and second molars above and below, which are replaced by permanent teeth.

By this it is seen, in some cases which are of great interest, that the horse at three years old not only casts twelve temporary teeth, but gets sixteen permanent teeth, viz. four central incisors, first and second molars on each side, above and below (eight), and the fifth molar.

From three and a half to four years old the horse casts his lateral incisors and the third temporary molar, which are replaced by permanent ones. At this period the sixth molar is coming into view; thus, at four years old, he casts eight temporary and gets twelve permanent teeth.

At five years old the corner milk incisors are replaced by permanent teeth. The canines or tusks appear. The horse is now full mouthed.

Cattle.—In cattle the incisors are shovel-shaped, with well-defined neck, and are found in the lower jaw only, and always loose in their sockets.

At birth, calves are frequently seen with eight incisors, all up. The development and shedding of teeth in cattle is very peculiar, varying from six to nine months, according to breed and mode of feeding; but the following may be taken as a fair average:—

At birth a calf may have from two to eight incisors and twelve molars, three on each side, above and below.

About six months after birth the fourth molar or first permanent makes its appearance; at fifteen or sixteen months the fifth molar is seen; and at two years the sixth molar is through.

About this period the two temporary central incisors are replaced by the permanent, which are very much larger; and the first and second inferior and first superior molars are thrown off, and six permanent teeth take their place.

The first inferior molar is very like a wolf-tooth in horses.

The second is frequently cast before the first.

The second superior molar is shed about three months after the first, or at about two years and three months to two years and six months.

The third inferior temporary molar is very peculiar, having three distinct sections or columns; it resembles the sixth permanent, but is not so large. It is cast at about two years and nine months to three years old. Shortly after this the third superior molar is shed. Sometimes the third inferior molar comes off before the second, and at times they have been removed both together.

The crowns or wearing surface of the molar teeth of cattle are

very unlike those of the horse, having short elevations and depressions resembling the teeth of the carnivora, and are well adapted for tearing down the rough grass.

Dental Diseases (Horse).—The condition of the teeth at times creates various disorders, disease, and even death.

When the horse is rising three, he is brought in from grass, and put to work. Owing to the new mode of living and the great dental irritation going on at this period, some animals suffer very severely, so that we need not be at all surprised to notice the commencement of certain disorders in horses. From frequent inspection of animals, from foals and upwards, it has been found very rare to notice any sign or symptom of chorea (shivering, string halt, or click-leg) until the animal is rising three years old. It is very probable that the irritation set up during the extensive dental process just referred to is the commencement of the above-mentioned nervous disorder through reflex action; more particularly so where there is an hereditary tendency to the disease.

Therefore, the most critical period of the horse's life is when he is rising three years old; for not only is there associated with it the before-named complaint, but also strangles. But whether this is partially due to the extensive dental process, or the change from outdoor to indoor life, or atmospheric influence, cannot be definitely stated.

Again, at this period, if true dentition is not going on, at times pus forms in the sinuses, or disease of the alveolar processes occurs, more particularly in the upper jaw, ending in softening and degeneration of the bone.

When young animals are suffering from retarded dentition they lose flesh, and the belly becomes tucked up.

Other symptoms are as follows: long shaggy coat, tight skin, ewe neck, thin thighs, flat ribs, dragging of the legs, walking with a listless gait, and also occasional diarrhœa.

If a colt is doing badly, and the teeth are suspected to be the cause, have the mouth examined, and any offending teeth removed. As "prevention is better than cure," it is a good plan, and one which is largely practised in Cumberland, to have the teeth of all young horses rising three examined by the veterinary surgeon some time from December to June.

When rising four years old a horse seldom suffers so much as at three years old, although there is an old saying that "a four-year-old horse cannot stand work as well as a three-year-old;" but this may be due more to the punishment he has gone through as a three-year-old, the effects of which he has not thrown off.

If at this period you find an animal not doing well, examine

the mouth, and, if necessary, remove the shells. As a rule, the lower come off sooner than the upper. In many instances, under the crowns, or between the shells, and top of the permanent teeth, there is a quantity of fœtor, as of diseased bone. It is very seldom that a cough is attributed to dentition, although it is possible.

With the exception of young horses casting their teeth, and old horses with unevenly worn surfaces, it is better not to give a horse *crushed or bruised oats*. It is preferable that the oats be given whole, so that the animal can have the pleasure of grinding them, thereby getting the full benefit of the salivary juices and their action on the starchy matters. Crushed oats are more liable to be bolted and produce choking.

The upper molar teeth in horses and cattle are much larger than the lower ones, the upper being a fixture, as it were, to give a broader surface for the rotary movement of the lower jaw to act upon, thereby, in aged horses, causing uneven wear and overgrowths, which have to be removed by the rasp and shears.

Many cases occur in which the molars are split by the animal getting some hard substance amongst its food. There is nothing worse in this respect than foreign barley. By removing the loose portion the animal generally does well; but the tooth becomes elongated or overgrown, and has to be cut or rasped.

Before drawing a tooth it is best to cast the animal. Aged horses should be cast with ropes, in the same manner as young colts are cast. Hobbles should not be used. It is not necessary to use chloroform for this operation, although some practitioners prefer it.

After removing the tooth, dress every third morning by plugging the hole with tow saturated with three parts water and one part tincture of iron.

Wolf-teeth are rudimentary, in the opinion of many veterinary surgeons, and do no harm.

Parrot-mouthed animals have to be closely observed, and the teeth dressed when necessary.

Cattle.—Teething in cattle often causes a great deal of constitutional disturbance, more particularly from one year and nine months to two years and six months old, by the temporary molars not being cast off, thus setting up teething-fever and, in many instances, fatal diarrhœa.

As a rule, a large number of stirks are examined by the country practitioner at the spring and fall, and, where necessary, the crowns are removed. Young animals, when suffering from retention of the crowns or shells, have tucked-up bellies, flat ribs, tight hide, dirty skin, eyes gummy and congested with mucous

discharge, feed very badly, suffer from diarrhœa, and drink large quantities of water.

The shells have frequently been found sticking between the cheek and gums in both upper and lower jaws.

Of course, any foreign substance, or anything wrong with the mouth generally, causes a large flow of saliva. The mouth should be examined, and the offending object removed.

In all cases where emaciation is great, give good food—milk, linseed jelly, and small doses of vegetable tonics.

The Brain and Nervous System.

Happily diseases of these important organs are not so frequent in horses and cattle as they are in the human subject. Horses sometimes suffer from inflammation of the brain from the hot rays of the sun or from some peculiarity of the food. As an example of this, take stomach staggers, caused by ergotized grasses and the heat of the sun combined. In dry hot weather the animal should at once be put under cover, and small and repeated doses of purgative medicine administered, say, every eight hours. In some cases four or five quarts of blood may be taken with advantage. Horses at times suffer from abscesses forming in the brain from neglected, protracted, or bastard strangles. Unsound food, such as mouldy oats and barley, if given for any length of time, produces irritation of the stomach and reflex brain symptoms.

Concussion of the brain may occur in the horse by his running away and coming in contact with some obstacle, or from falling backwards and fracturing some of the bones of the skull. The animal generally loses power and becomes insensible. Cold-water applications should be applied to the head, but if the animal cannot move his legs on being pricked with a pin, he should be destroyed.

Vertigo, or *Head Staggers.*—This may be due to some mechanical pressure of the collar preventing free circulation and producing oppression of the brain, more particularly in going uphill. Tight reining up with a bearing-rein may also cause it. When attacked, the animal staggers several times, and then falls. After a few ineffectual attempts to rise, he finally gets on his legs again, and may resume the journey. Such horses are best suited for farm purposes and slow work.

Apoplexy is very rare in the horse, and is either due to a rupture of some of the brain bloodvessels, or to a clot of blood forming in one. It is very sudden in its attack, and is accompanied by paralysis of one or both sides.

Epilepsy is mostly seen in dogs, particularly those that have

suffered very much from distemper. When attacked, allow the animal plenty of fresh air, dash cold water over the head, and, to prevent the tongue from being bitten, a piece of wood may be put between the teeth. Occasional doses of opening medicine should be given, with small and repeated doses of bromide of potassium.

Tetanus, or *Lock-jaw.*—This formidable disease is of frequent occurrence in the horse, and, although said to be a nervous affection, it is now thought to be due to a bacillus or germ. It is most frequently produced by simple wounds, particularly those of the feet, and rarely shows itself until the wound is on the point of healing. Strange, though true, the writer has for nearly forty years attended horses in the bottom of coal pits—the injuries there are most frequently found in the feet—yet he cannot call to mind one case of tetanus amongst them, whereas the principal causes of tetanus that he has seen above ground have been due, as above stated, to wounds in the feet. This shows that the atmosphere has something to do with producing tetanus. When observed, the animal must be removed to some quiet dark loose box. The first symptoms are straddling of the hind legs, elevation and quivering of the tail, body stiff, and nose poked out. The confirming symptom is to slightly elevate the head by putting the hand under the chin, and so watching the eye. The eyeball is retracted within the socket, and the haw (*Membrana nictitans*) is pulled right across. After getting into a box, if possible give a dose of opening medicine with sloppy gruel and linseed jellies and milk to suck. In this dissolve two or three drams of bromide of potassium, which can be given several times a day. The animal should be put on slings, and kept thoroughly quiet and free from all excitement. If once an animal gets down it very rarely rises again, unless raised with blocks and slings.

Chorea, or *String-halt*, is said to be a disease of the nervous system. It seems to be hereditary in some breeds of horses, resembling *St. Vitus's Dance* in the human subject. It is characterized by peculiar muscular action of the hind legs. It affects the dog as well as the horse, and in the former can generally be traced to an attack of distemper. It at times affects only one ear or one limb, and cases are known where only the tail had a peculiar jerk when the dog was standing still. The writer has an opinion that in the horse the shedding of milk teeth is one cause of the production of this disease. Be this as it may, the animals may do slow work for years. They are generally worst at backing or going down a hill, but can pull a load with ease when going forward. When very bad, half-ounce doses of bromide of potassium have an excellent effect.

Hysteria is sometimes seen in young heifers of two years old,

causing great nervous excitement, and occasionally terminating in a fit. It is usually seen about the time the animal is coming into heat. A good dose of opening medicine with two drams of extract of belladonna soothes the patient.

Tubercular disease frequently affects the brain and spinal column. It is often found in high-bred cattle.

Sturdy, or *Gid*, is a disease affecting sheep and young cattle. It is caused by a parasite or hydatid found in the brain, and is developed from a segment of the tapeworm of the dog (*Cœnurus cerebralis*). It is mostly found on hill pastures, where a number of dogs are kept. Any part of the brain may be attacked, but when in contact with the skull it may be removed by an operation. The bones of the skull become soft over the situation of the hydatid, and this indication may easily be felt with the finger. The operation must take place at that point.

Rabies is a disease common to the dog, and of a frightful character. It affects dogs principally in hot weather. The bite of a rabid beast has most fearful and fatal results. All such animals should be destroyed at once.

DISEASES OF THE EYE are, happily, not numerous in the horse. Anything interfering with the organs of sight is of first importance, requiring careful attention in examinations as to soundness. The affections are generally due to injury. Thus an irritable rider may strike the horse over the head with a stick, producing inflammation and opacity of the cornea or covering of the eyeball. Sometimes we have inflammation of the lining membrane of the eyelids, which is also reflected over the front of the eyeball. This is generally caused by foreign bodies, such as hayseeds or chaff, getting in. The foreign substance must be removed, and soothing treatment, such as the application of cold water, adopted. Should any constitutional disturbance intervene it must be treated accordingly.

Ophthalmia is inflammation of the internal structures of the eye. It occurs more frequently in towns than in country practice. It is supposed to be due to bad ventilation and dark stables. At one time it was thought that the moon had some influence, and it was called "moon blindness."

Good sanitation and ventilation tend very much to prevent its occurrence.

At times we have ulceration of the cornea, more particularly in the dog. Stimulating treatment is required: a weak solution of nitrate of silver or solution of boracic acid gives the best results.

Cattle during the winter months suffer greatly from chaff getting into the eye. It is then a common practice of the farmer

or cowman to blow powdered alum or glass into the eye for the removal of the chaff, thus causing great pain to the poor animal. This the writer strongly condemns. With a pair of fine-pointed forceps the chaff is easily removed.

If the inflammation be great, a little cocaine put into the eye destroys the sensibility, and the offending body is readily extracted. The eye should be bathed with cold water, and afterwards a little boracic acid solution applied.

Cataract, which is opacity of the crystalline lens, is of two kinds. It is due to inflammation of the structure of the eye, but in old animals, and particularly the dog, it comes on gradually.

There are many other minor affections, such as warty excrescences, fungoid growth, worms in the eye, etc., which we have not space to give in detail.

The EAR of the horse is rarely affected, except from injury. Rare cases are met with where a tooth at the base of the ear is found to be setting up irritation, and causing a sinus with discharge from the edge of the ear.

The dog, however, suffers from a disease called **Canker**, which is very troublesome and objectionable. It chiefly affects house-dogs, and is principally due to over-feeding and plethora. The dog shakes his head, and, on examination, a dirty fœtid discharge is seen in the lower part of the ear. Change the diet, give plenty of exercise, and blow a little iodoform into the ear every second or third day ; this has a radical effect on the complaint.

DISEASES OF THE SKIN.—Amongst these we have **Variola**, or *Vescicles*. Small pustules form all over the body, and discharge a little acid secretion, which is very irritative, besides being contagious, and troublesome to other horses. It is very bad to get rid of. Saddles and harness of the patients should never be used for other animals. Washing with phenyl and water—1 to 50 parts —with a little alterative medicine, is all that is required.

Mange, or *Scab*, is due to parasites of various kinds, and affects the horse, ox, sheep, dog, and man. It is very troublesome, and at times bad to manage. The principal agents used for treatment are sulphur, spirits of tar, and whale-oil combined ; dressing the affected parts every second or third day. Wash the animals with carbolic soap and soda once a week. Saddles and harness must also be attended to.

Mud Fever.—This is a kind of superficial inflammation of the skin of the legs. It is most frequently seen in winter, in cold sloppy weather. Washing the legs seems to increase the complaint. The best remedy is to keep the legs as dry as possible, in fact, leave the mud to dry on the legs and rub off with a wisp of hay. This is much better than washing the legs and not drying

them. Washing with phenyl and water, if the legs are very sore and painful, has a good effect. Constitutional disturbance, caused by the inflammation in the skin, if present, must be attended to.

Mallenders is a species of local inflammation affecting the skin at the back of the knee-joint. **Sallenders** is a similar complaint at the front of the hock-joint. They are both of the same nature, and seem to affect certain breeds, particularly the cart-horse class, with gouty, gummy legs. A dressing of reduced mercurial ointment two or three times a week sometimes answers well.

Grease is a disease of the skin, and principally affects cart-horses. It is a very troublesome complaint when it once gets established. It affects the hind legs oftener than the fore. It is known by a fœtid discharge from the glands of the skin, and, when observed, ought to be attended to immediately.

Ringworm is another parasitic affection of the skin of horses, cattle, and dogs. It is most frequently seen in young cattle during winter, when confined to the straw yards, and often affects the cowman also. It should have prompt attention when seen. Dress twice or thrice a week with sulphur, tar, and oil mixture.

Warts, or *Angleberries*, are very common on some horses and cattle. Some constitutions seem predisposed to them. When numerous, they interfere with the growth of the animal, and should be removed without delay either by hot iron, knife, or écraseur.

Warbles are sometimes seen in horses, but more commonly in cattle. They are due to an insect, called the *Æstrus bovis*, depositing its eggs on the back of the cow in the summer months. These eggs develop into warbles during winter, and leave their winter habitats in the spring months. When young animals are put out in the summer, their backs should be smeared with sulphur, spirits of tar, and oil, as a preventive, or give a good washing with strong salt and water once a month. For further particulars, the reader is referred to the works of Miss E. A. Ormerod.

DISEASES OF THE KIDNEYS are of very rare occurrence in both horses and cattle. The one most common in horses is **Diabetes insipidus**, or *Diuresis*, profuse staling, frequently following debilitating diseases, as influenza and strangles. It is at times caused by eating heated oats and bad hay. The animal has great thirst; in fact, some will go down on their knees to drink out of the filthiest pond possible. The belly is tucked up, coat staring, general debility. Although the appetite is not much impaired, the animal continues to lose flesh, and has an almost continuous flow of urine. The best treatment is one-dram doses of iodine, made into a ball, to be given every night, three or four

hours after the last meal. Give good nutritious food of not too starchy a nature.

Inflammation of the Kidneys is very rare, both in horses and cattle. At times this inflammation terminates in an abscess in one of the kidneys. If in one only, the remaining kidney becomes enlarged or hypertrophied. The disease is caused by standing in cold, damp places.

The symptoms are very obscure. The animal shows little or no pain, giving only an occasional moan, but is very dull and listless, with a temperature up to 104° or 105°. It staggers about like a drunken man, swings its head from side to side, and occasionally falls on its sides, manifesting all the symptoms of uræmic poisoning.

Ischuria, or *Retention of the Urine*, may be due (1) to suppressed action of the kidneys, as in fever or inflammation of the kidney; or (2) to the bladder being greatly distended. The latter point may be caused by spasm of the neck of the bladder (due perhaps to the application of a fly-blister or the administration of turpentine), or by some obstruction in the passage of the urethra. If from the latter, the obstruction must be cut down upon and removed. If from spasm, the catheter must be passed and the urine drawn off.

The symptoms are frequent attempts to urinate, stamping of the feet, and turning of the head to one side. Long journeys, and horses being put in stables with no straw, are the chief causes.

In the mare and cow, this retention of urine is sometimes due to the passage being damaged in difficult cases of parturition. Inflammation of the parts is set up, and this must be treated by hot fomentations and warm-water injections into the rectum and vagina, with removal of the urine by the catheter.

In the treatment of the foregoing complaints, either in horses or cattle, small doses of raw linseed oil (say ten ounces) with one ounce chlorodyne, every eight hours, will be found beneficial.

Inflammation of the Bladder.—This is comparatively rare, and is generally due to damage done during difficult parturition, or to the improper use of strong diuretics, such as turpentine, etc. The symptoms are continuous straining to urinate, and the ejection of a little bloody urine.

Apply hot fomentations to the loins, or, better, a large poultice of Indian-meal porridge in a bag laid across the loins. Give small doses of linseed-oil and chlorodyne, as in the last case.

Abscesses have been found in the bladder. These, also, are the result of damage in difficult parturition. The symptoms are frequent straining, as if about to calve. From the peculiarity of the complaint, it should be put in the hands of a qualified man.

Gravel, or *Calculi*, are also at times found in the bladder. This, also, should be treated by a qualified practitioner.

It has been found that bulls fed on mangolds become unfruitful. The reason is thought to be owing to a large number of white crystals forming in the bladder and urethra; these are transmitted with the seminal fluid into the uterus, and prevent proper conception. These white crystals are found, on blow-pipe analysis, to be ammonium-magnesium phosphate.

The same crystals are also found in the bladder and urethra of rams and wethers, collecting in such quantities in the vermiform appendage at the end of the penis as to entirely block up the passage. This causes continuous straining to urinate, and, if not relieved, they die from rupture of the bladder or uræmic poison. Making an opening with a lancet at the base of the "worm" has in many cases been highly successful, without at all interfering with the generative powers of the ram.

In wethers the "worm" might be cut off. The complaint is most frequently seen where the sheep are folded on turnips grown with superphosphate. As a preventive, the tops of spruce or fir trees might be placed in different parts of the field. The sheep eat the green portions and bark of the tree with great relish and benefit.

Small **Calculi** are at times found in the urethral tract of dogs and horses. They must be removed by cutting down on them. This must be done by a veterinary surgeon.

In the *Fossa navicularis*, at the end of the penis of the horse, collections of a sebaceous character accumulate, until at times they become so large that, by pressing on the end of the urethra, they cause much pain. From nervous reflex action of the pain, the animal in some cases is unable to stir either hind leg; others go lame on one leg only. When suspected, examine the parts and remove the collection.

The Female Organs of generation are also liable to derangement and disease.

Vaginitis, or inflammation of the lining of the vagina, is principally due to injury from difficult parturition. It may also be caused by contact with an unclean male. The latter produces a vesicular eruption all over the mucous surface. In the cow the external parts are slightly swollen, with a thin discharge coming from the vulva; the animal is constantly rubbing the parts with its tail, as if great itching was experienced. Inject a solution of boracic acid (say ½ oz. to 1 pint of warm water) once a day into the vagina. Give a mild dose of laxative medicine to the cow, —4 ozs. Epsom salts, ½ oz. saltpetre, 1 oz. powdered laurel berries, 1 oz. ginger. This is to be administered every 12 hours,

until 4 or 6 doses are given. With the mare, inject into the vagina boracic acid solution, and give half-ounce doses of chlorate of potash every night in a bran mash. Give a slight dose of laxative medicine.

In some parts of the country, a complaint peculiar to *white heifers* is very common, and known by the name of **Impervious Os.** This is obliteration of the passage to the womb. It is usually seen in animals from two to three years old, and symptoms of the complaint are rarely shown until after having been served. About a fortnight or up to six weeks after being in contact with the male, the animal commences to pain and strain as if about to calve. The case must be attended to immediately, and, on examination, by passing the hand well oiled into the rectum, a large distension is found in the pelvic bones and under the floor of the rectum. The fluid must be drawn off by an operation with the trocar and canula. After removal of the fluid, the parts should be well washed out with 1 gallon of tepid water and 1 oz. of tincture of iron, put in by the injection pipe. The writer has operated on a large number of cases, both before and after the heifer has been in contact with the male. In one case the animal was only nine months old. It is needless to say that these animals are of no use for breeding purposes, and must be fattened off.

Abortion in Cattle.

This is a most important matter, not only to the stock-owner, but also to the veterinary profession.

Abortion arises from a large number of causes. We may have a solitary case and no more. Again, we have cases that spring up where no cause can be attributed, and then pass like an epidemic throughout the district. The most frequent cause that has come under the writer's observation, is that where a farmer is changing his holding, selling off his own original stock, and getting his new herd from various sales, auction marts, etc. The pregnant cows, being obtained from different places, are perhaps three parts gone in gestation. They are, perhaps, tied up in the byre on the unaccustomed side and with strange companions. One more nervous than the rest frets, and finally casts her calf. The result is that all the pregnant animals follow her example. Another cause is that of putting pregnant animals on marshes or grazing pastures to associate with cattle from different parts. Very possibly some of these animals may have recently aborted or cast their calves. The in-calf cows readily become infected, and the result is that abortion is brought on and rages like an epidemic.

Immediately a cow is showing signs of parting with her offspring, she ought to be taken out of the byre from amongst the other pregnant animals. She should be put into a box, and left there to calve by herself. No cow should be allowed to calve in a byre amongst other pregnant animals at any time, whether abortion be prevalent or not. Even when no abortion is on the premises, a cow, up to her full period, in the act of parturition, through sympathetic action on the part of one or more of her in-calf companions, may cause them to cast their calves before the proper time. Abortion may then be set up in the stock. Every stock-breeder, therefore, should have one or more nursery boxes, into which cows may be turned to calve by themselves.

It is scarcely necessary to add that cleanliness and sanitation should be looked to in the byres. Lime-wash with carbolic acid should be freely used on the walls. The writer does not agree with the method of injecting germicide mixtures into the generative organs of pregnant animals.

Parturition.

The same method of operation usually answers in mares, cows, and sheep. We will take the natural presentation in a fat shorthorn heifer, first calf, where the opening is constricted but the ligaments quite relaxed. The two fore feet protrude through the opening. These are usually seized by the attendants, and pulled till both shoulders and the head are jammed tight in the passage. The fœtus is, however, extracted with a great deal of main strength and stupidity, and often the vagina is so much torn that fatal hæmorrhage occurs. To perform the operation properly, begin by oiling the hand well, and then introduce it into the passage. Examine the head and all its surroundings; then pass a string or cord over the head and behind the ears of the calf, making a loop in front outside by knotting the ends. By traction on the cord and manipulating with the other hand, deliver the head, occasionally pulling first one leg and then the other. The fœtus then generally comes away. At times, however, other difficulties are met with, such as dropsy of the abdomen of the calf. In this case the head and fore legs are presented in a natural position, but still the fœtus cannot be extracted. On passing the hand over the head, neck, and shoulders of the calf, the belly is found to be of an enormous size, preventing delivery. A special finger knife or trocar is passed up, and an opening made into the side of the calf. The fluid comes away and the calf as well, without any trouble.

The next presentation is a very common one, both in the mare

and cow. It is where both fore legs are presented, while the head is bent back, the nose pointing behind the elbow. This case is sometimes very troublesome, but, if attention be paid at an early stage, it is managed simply enough by passing a cord to the under jaw and giving it to an assistant to hold; then, by pressing the fœtus back and working the head over the shoulder, get it into a natural position, and the operation is soon finished. Sometimes, however, and this happens too frequently, the fœtus is dead, the uterus has contracted on its contents, and a nasty acid secretion is found in the womb. The hand cannot then be introduced to make examinations with freedom. In these cases a quantity of strained linseed jelly should be injected into the womb with Reid's patent enema syringe; this is a great help, as it distends the walls of the uterus, and acts the part of the natural fluids.

If the head cannot be got into position, the fore legs must be removed. Passing an embryotomy knife on the shoulder of the fœtus as far as can be reached, the operator draws the instrument carefully and firmly along the whole length of the limb, and cuts through the skin from the shoulder to the fetlock or middle of the shank, as required. Then, with the fingers, skin the limb up the shoulder and as far as can be reached. Strong cords having been attached to the pastern, or above the knee if practicable, cut through the pectoral muscles, and pull the limb away. Do the same with the other leg. Having lost the support of the fore limbs, which have been holding it up, the fœtus drops to the bottom of the womb. There is then a chance of reaching the head, and, by the use of hooks sunk into the different parts of the neck, and pressing the body of the fœtus back, the head is got into position, and successful extraction of the partially dismembered body follows.

In the mare this presentation is a very frequent and a very formidable one, more particularly when the head is bent back and lying on the quarter. In fact, when the foal is got away, the bones of the face are so concave that they exactly fit the quarters. Two or three pains are sufficient to jamb the fœtus against the pelvis of the mother, while the legs project outside to above the knees. It is impossible to turn the foal's head round so long as the two fore legs are projecting from the passage, the fœtus being pressed up against the spine of the mother.

When a case of this kind is met with, make a very careful examination. If only the tips of the ears can be reached, neither the strength of the patient nor that of the operator should be wasted. Proceed at once to cut the foal away in the manner already described above; remove the fore legs and turn the head round. Cases of this kind are, however, met with, both in the mare and

cow, in which the ribs have to be cut into. Twist one or two off, put the hand into the abdominal and thoracic cavities of the fœtus, and remove their contents. The head can then be turned and extracted easily.

There are several other minor cases in which the fore legs are presented, and the head turned on the shoulder, or it may be with the nose pointing into the flank, or the head turned on to the back of the fœtus with the lower jaw upwards. These are removed in a somewhat similar manner to those already described. The legs are secured, and the head brought round by cords and hooks, meanwhile pressing the fœtus back into the body of the womb. Again, the fore legs may be presented with the head doubled down under the neck, and the occipitus of the fœtus presented at the brim of the pelvis. Secure the legs with ropes, and also put one round the lower jaw, or insert a hook into the eye socket. Press the fœtus back, and lift the head into position.

A somewhat formidable-looking presentation is met with where all four legs are found in the vagina, with the head thrown back and out of reach. This can be made a very long and tedious operation, or a very short one, according to the manner in which it is done. It is a very common presentation in the mare. After careful examination, attach cords to the hind pasterns, press the fore limbs back, pull first one and then the other of the hind limbs through the vulva, and you will generally succeed in the removal without any cutting at all. It frequently happens, however, that some one has pulled the fore legs out too far to be returned with safety to the mother; the fore legs must then be removed at the shoulder, and the hind limbs drawn forwards as already described.

The next is the breech presentation. In the mare, when the tail only is presented and the points of the hocks cannot be found, the case looks desperate. After satisfying yourself that the legs cannot be got, and only the tail and quarters are to be felt, waste no time. With an embryotomy knife in the hand, reach as far over the stifle of the fœtus as possible, plunge the knife through the skin, and cut steadily through the muscles over the hip joint towards the tail, cutting and tearing down the tissues until the joint be reached. Divide the ligament—rather a difficult task; set the head of the femur at liberty; attach a good strong plough cord around the neck of the femur, and give it to an assistant to draw. Then with the knife divide the muscles on the inside of the thigh, and for this purpose nothing beats the ordinary shoeing knife. The greatest difficulty is in cutting through the fascia and skin inside of the thigh, but you will succeed in this as the limb

is drawn head foremost into the passage. When the leg is removed, next cut into the abdomen, pass in the hand and tear out the viscera, both abdominal and thoracic. Attach a rope to the pelvic opening, and have an attendant steadily pulling it, while the remaining leg is pressed up against the now emptied belly. Lift the fœtus into the passage. This is usually successful, but cases are met with where both hind legs have to be removed, as well as the viscera, before delivery can be accomplished.

The next case is where the hind legs are presented transversely across the womb, with the points of the hocks opposite the passage, and neither the feet nor stifle in reach. With difficulty the legs may be cut off by the hock joint. Instead of this, by dividing the tendon achilles, flex the shank against the front of the tibia, first passing a cord round the joint. Extraction then follows. When the points of the hocks are found at the brim of the pelvis of the mare, by pressing the fœtus forward with the repeller and getting the hocks up towards the spine of the mother, the hind feet may be placed in position.

In cows these breech presentations are generally very simple, and removed in the manner just shown.

Ectopia abdominis is sometimes found in the calf. The hind legs are doubled forward over the back and on to the shoulders, with the head and fore limbs flexed backwards also on to the shoulders. The walls of the abdomen are partly reflected over the limbs and head, and the bowels are floating loose in the womb of the cow. When the abdominal viscera of the fœtus are presented, first remove them by tearing away with the hand and then with a good knife—a shoeing knife preferably. Cut through the spine and reflected integuments, the latter operation being more difficult. Then with hooks take either the hind or fore portion, whichever is most favourably presented, and pull it away.

Hydrocephalus, or water in the head of the calf.—Press the embryotomy knife into the bladder-like head. The fluid escapes and extraction becomes simple.

With *Twin Calves* be very careful in examining and securing the legs and head proper to each calf. Sometimes the fore leg of one, and the hind leg of another are drawn into the passages; at other times the head of one calf and fore legs of another.

Constriction of the Os uteri.—In the cow it is known in Cumberland as "Horny Lyer." Smear the parts well with extract of belladona, and give the animal two drams of gum opium suspended in hot water. Then wait a few hours before attempting removal. If the labour pains are very strong, pass a cord round the body of the mother, and through it put a stout stick. This is

used by an attendant to twitch and tighten the rope, thus preventing the abdominal muscles from strong and violent action until the opium takes effect. Sometimes the os has to be cut, but in these cases you must not only have patience, but *exercise it.* Generally, the belladonna application, the opium, the involuntary contraction of the muscles of the uterus, and the exercise of patience succeed without any cutting whatever.

Retention of the Fœtus is occasionally seen in cows. At the end of the gestation period, the pelvic ligaments become relaxed, the outer parts freshen, the udder distends, the teats stiffen and become pointed. All seems in full and natural condition for calving; but there are no symptoms of labour pains. Finally the ligaments tighten up, the udder scales away, and the animal commences feeding. Strange to say, different bones belonging to the fœtus, such as the jaw, scapula, ribs, humerus, and several others, are passed at times through the rectum. These are interesting cases.

Well-bred sheep in frosty weather frequently have **Eversion of the Vagina,** particularly of the upper portion, with the os uteri constricted, and the ewe paining very much. Smear the vagina all over with extract of belladonna, and return it. Then, to keep it in position till the os dilates, put two stitches of tape across the opening, and give the sheep from 8 to 10 ozs. linseed oil, and ½ oz. tinct. opii. P.B. If the weather be mild they generally do well, but if severe frost, the case may end in inflammation and gangrene.

In all cases of difficult parturition in the mare wait about six hours, and if by that time the after-birth does not come away, it must be removed. Then wash the uterus out well with two or three gallons of tepid water, and, after this has been expelled, inject the uterus with 2 gallons tepid water containing 1 oz. tincture of iron. Give the following draught:—

Linseed oil, 1 pint.
Tincture of opium, B.P, 2 to 3 oz.
Aromatic spirits of ammonia, 2 to 3 oz.

In some seasons the retention of the placenta in the mare appears almost as an epidemic. If it is not removed within twelve hours after parturition, it is usually followed by laminitis or pyæmia and death. Cattle, on the other hand, can retain the placenta for from six to eight days without any inconvenience.

Great care should be used in removing the placenta from the mare; the least portion left will cause a great amount of constitutional disturbance. Mares out at grass can retain the placenta a much longer time without any bad effects than those in the stable.

Many serious accidents are met with in parturition in the mare. At times the fore feet of the fœtus are pressed through the top of the vagina into the rectum and out at the anus. All haste must be exercised in pushing the fœtus back and putting the feet into their proper position. The wound thus made rarely heals up, as the parts are never at rest, on account of the muscular action of the rectum. Some of the fæces pass out through the vulva. Mares have been known to breed with this defect without any bad consequences.

Again, the same accident is succeeded with more serious results when, by the pains of the mother, the limbs tear through and make the passages into one. This, of course, never heals, and the fæces and urine come from one common opening. Immense sloughing of the neighbouring parts sometimes takes place.

Eversion of the uterus is very common in the cow, and in many cases it is only returned with difficulty; but in the mare it is extremely rare. These are cases consequent to parturition. At times the bladder is everted, and the animal has considerable straining and paining, with a constant dribble of the urine from a yellowish-blue bag hanging from the opening. It is readily returned, but difficult to keep in its place.

Post-partum Hæmorrhage.—In these cases a cotton bed-sheet should be put into a bucket of cold water, to which is added 1 oz. tincture of iron. The cloth is partially wrung out and then packed into the vaginal canal, leaving it till it comes away by itself in the same way as if the animal were cleansing. Then keep her quiet.

Milk Fever.—The attack comes on within twenty-four hours of calving; the cow staggers, then lies down on her sternum, turns her head on her shoulder, and breathes heavily. It is greatly due to three shocks—(1) the expulsion of the fœtus, and the expansion and relaxation of the womb; (2) taking away the calf from the cow; (3) drawing off all the milk. High feeding causes a tendency towards it. As a preventive give 2 lbs. castor oil seven or eight days before, and two to eight hours after, calving. Leave the cow and calf together for a few days, or draw off only two-thirds of the milk each time for five days. When the attack begins, prop the animal up, and give 1 pint of whiskey. If it falls into a comatose condition, give 1 pint whiskey, 1 quart beer, 2 lbs. treacle, and 4 ozs. mustard. Dash cold water over the beast, and keep a cold-water blanket around it.

CHAPTER VII.

AGRICULTURAL ENTOMOLOGY.

THE pests attacking crops are either (1) animals or (2) plants. Those belonging to the former class are chiefly insects; those of the latter are generally fungi.

(*a*) INSECT PESTS.

Insects belong to the great sub-kingdom, Invertebrata (those without backbones). Their division of Insecta is divided into the two tribes of Mandibulata (biting-mouthed) and Haustellata (sucking-mouthed). These are divided again into the following orders, chiefly with reference to their wings:—

I.—*Mandibulata.*

Order.	Characteristic.	Examples.
1. Coleoptera ..	Sheath winged ..	Beetles.
2. Euplexoptera ..	Tightly-folded winged ..	Earwigs.
3. Thysanoptera ..	Fringe winged	Thrips.
4. Orthoptera ..	Straight winged	Crickets, grasshoppers.
5. Trichoptera ..	Hairy winged	Caddice flies.
6. Neuroptera ..	Nerve winged	White ants, May flies.
7. Hymenoptera ..	Membrane winged ..	Saw flies, wasps, bees.
8. Strepsiptera ..	Twisted winged	Bee parasites.

II.—*Haustellata.*

Order.	Characteristic.	Examples.
1. Lepidoptera ..	Scale winged	Butterflies, moths.
2. Diptera ..	Two winged	Beet flies, Daddy Longlegs.
3. Aphaniptera ..	Imperceptible winged ..	Fleas.
4. Homoptera ..	Similar winged	Aphides.
5. Heteroptera ..	Dissimilar winged ..	Plant bugs.

PHASES OF INSECT LIFE.

All insects pass through certain changes before being full-grown, and it is very rarely that the mature insect is similar to the one which comes out of the egg.

The Egg.—Insects are either hatched from eggs (oviparous), or produced alive by the female parent (viviparous). The eggs of the cabbage butterfly can readily be obtained from the under surface of a cabbage leaf and examined. They are of a whitish or yellow colour, elliptical, and are fastened to the leaves by a gummy secretion. The eggs are seen to contain a small speck or embryo, which gradually increases in size, and at length bursts its coat. The embryo is now known as the Larva (grub, caterpillar). It should be remembered that insects are never produced by vegetable or other organic matter, but only by other mature insects.

The **Larvæ** are generally long cylindrical fleshy grubs, with or without a few pairs of short fleshy legs, and often with a somewhat rudimentary mouth. The larvæ of coleoptera are usually fleshy grubs, having scaly heads furnished with jaws; sometimes they are legless, but commonly have a pair of short legs on each of the three segments next to the head; and the last segment of the body has often a fleshy foot beneath it. Those of the Lepidoptera are nearly cylindrical, long, soft, and variously coloured, spined or tubercled; the head is scaly or horny, bearing eyes, jaws, and a pair of short horns; the three segments next to the head have usually a pair of horny feet on each, and of the remaining nine segments the tail and the four intermediate ones are usually each furnished with a pair of sucker feet. The grubs of the Diptera are fleshy and generally footless, sometimes having a hard head furnished with nippers or jaws; but often are cylindrical, truncate at tail, and elongated at the anterior extremity, which contains a soft mass answering for the head, and bearing a pair of hooks instead of jaws. (Miss Ormerod.)

The larva eats voraciously, and increases in size, casting off its coat, or moulting, whenever it becomes too little. It at length reaches a certain stage, when it spins a cocoon round itself, and changes into the pupa, or chrysalis.

The Pupa.—In this state the perfect insect begins to gradually form, and it is a kind of transition state between the grub and the mature winged form. The nervous structure is rearranged; the segments of the body become united to form the head, thorax, and abdomen; the legs are confined to the thorax; wings form; and the whole structure is more perfectly developed. At length the outer covering is cracked, and the insect slowly draws itself out of its tightly fitting case, and may now be said to be mature. The wings gradually expand and the body coat hardens.

Imago is the scientific name of the perfect insect. Pairing soon commences, and then the male usually dies. The female,

however, is of longer life, having to deposit her eggs. In some species both male and female live through the winter and reappear in spring.

We will now consider briefly the chief injurious insects, taking them according to their orders, and giving the prevention and remedy.

Insects belonging to the Coleoptera.

Apple-blossom Weevil (*Anthonomus pomorum*).—These attack the young apple-blossoms, biting a hole into the yet unopened flower, and then the female lays an egg inside the corolla. Eggs hatch in April; the grub feeds on the inner parts of the flower, causing it to die away. The maggot turns into the chrysalis in the bud, and in about a month the weevils come out. They feed chiefly on the apple leaves, and live under the rough bark and various kinds of rubbish until next year.

Remove all rubbish and rough bark. Place bands of some sticky material round the tree, and thus prevent the female from creeping up. Keep the trees well pruned. Spraying with solutions of soft soap, mineral oils, ammoniacal liquor, tobacco-water, or of Paris-green (¾ lb. to 150 gallons water) has succeeded.

Bean Beetle (*Bruchus rufimanus*).—The female lays her eggs on the ovary of the flower; the maggot soon hatches and eats its way through the tender pod into the forming seed. Here it feeds, and at length changes into the chrysalis, from which the beetle comes out in spring. The beans thus attacked have large holes in them, often covered by the skin, and, although the germ is rarely attacked, are of little use for seed.

Always use good seed. Soaking the beans in water, or in weak solutions of copper sulphate or carbolic acid, is said to kill the beetle.

Cabbage Gall-weevil (*Ceutorhynchus sulcicollis*).—The female lays her eggs in small holes on the cabbage root or the turnip bulb. The maggots feed inside these galls, which soon tend to cause the whole root to decay. The maggots, when full-grown, leave the galls, and, after forming an earthy case round themselves, change into the pupa in the soil. The beetle may be found in spring.

Burn all cabbage-stocks as soon as taken from the land. Apply about two tons of gas-lime per acre in autumn. Wood-ashes, or ashes, and soil with a little paraffin oil may be used.

Wireworms (*Agriotes lineatus, A. sputator, A. obscurus*).—Wire-worm is the name commonly applied to the grub of the click beetle or skip-jack, so called from its manner of gaining its proper position when laid on its back. The egg is either laid on the ground or

on leaves close to the ground. When hatched, the maggots eat into the stem slightly below the surface. They feed on the roots and stem of many plants, but particularly on those of wheat and grasses, for from three to five years. They feed very voraciously, and are seldom injured by cold, as they go deeper and deeper into the earth during frost. When about to form the chrysalis, they go deep into the soil, and form an earth cell. In about a fortnight the perfect beetle comes up, generally in the middle of summer, and the rotation commences again.

Close graze the pastures, and then put sheep on, or roll so as to consolidate it. Apply fresh gas-lime, quicklime, or salt (5 to 10 cwt. per acre), so as to kill the pest. Paring and burning, clears away many insects. Rape dust draws the attack off the crop, and, applied at the rate of two or three tons per acre, soon clears the field. Superphosphate, guano, and nitrate of soda are used to promote a strong healthy growth of the plant.

Turnip Fly, *or Flea Beetle* (*Haltica* [*Phyllotreta*] *nemorum*). The turnip fly is a very small, black, or greenish-black beetle, having a broad yellowish stripe down each wing-case. During the winter the flea beetle remains under clods of earth, straw, fallen leaves, etc., and in spring begins to feed on cruciferous weeds, attacking the turnips when in the rough-leaf state. The eggs are laid at the rate of one per day, on the under surface of the rough turnip (or other cruciferous) leaves. Maggots hatch from these in ten days and immediately begin the attack, boring into the leaf and feeding on the soft tissues inside. After six days, they come out of the leaf and bury themselves just below the surface of the ground, changing into the chrysalis form. The perfect beetle comes up in fourteen days, and begins to cause immense damage by devouring the leaves.

Clear away all cruciferous weeds (such as shepherd's purse, charlock, wild radish, garlic mustard, hedge mustard, etc.), as it is on these that the fly lives until the turnips have sent up their leaves. Keep the land moist, if possible, by not working it too much in spring, getting, however, a fine tilth. For this purpose the cultivator is specially adapted, as it does not expose fresh soil to the air. Use plenty of seed, and apply some active fertilizer to push the plant on as rapidly as possible through the time of the seed-leaves. Nitrate of soda and guano are often used for the latter purpose. Some farmers drive sheep or drag bushes over the rows when the dew is on the leaf. The beetle cannot jump then, being clogged with moisture, and consequently many die. If a door be tarred, put on wheels, and dragged across the turnip field, many flies, in jumping to get out of the way, will stick fast to the tar. Mr. Fisher Hobbs

recommends the following dressing, to be applied in a fine powder early in the morning when there is plenty of dew on the leaf: ½ bushel gas-lime, ½ bushel fresh lime, 3 lbs. sulphur, and 5 lbs. soot per acre. The strawsonizer is an excellent machine by which to apply the mixture. Another dressing, to be applied at night, consists of 1 bushel of fresh lime, 2 bushels of road-scrapings, and 14 lbs. sulphur.

Mustard Beetle, *or Black Jack* (*Phædon betulæ*).—The beetles pass the winter under any convenient shelter. In the spring they commence to lay eggs and then quickly die. The grubs, which hatch from these eggs, are very voracious, and turn to chrysalids in the ground. The summer beetles come from these in fourteen days, and commence at once to destroy the mustard crop.

Burn all the straw, if possible. If the crop appears to be failing, plough it into the ground. Growing no mustard on the land for several years causes the numbers of insects to lessen greatly. The beetle is very sluggish in its flight, and hence its progress from one field to another can easily be stopped by burning damp straw. Dressings of any kind are of little use.

Clover Weevil (*Apion apricans and A. assimile*).—The weevils (which are pear-shaped and have long probosci) pair in spring, and the female then begins to lay her eggs in the clover blossoms. The larvæ feed on the ovules (seeds) of the flower. When full grown they change into the pupa form at the base of the blossom. The weevils come out in a fortnight, or may remain till next spring.

Do not grow clover for several years. If attacked, mow the clover when green and feed at once, or make into silage. Burn all refuse heads seen.

Insects belonging to the Thysanoptera.

Corn Thrips (*Thrips cerealium*).—The thrips is a very small black insect, attacking corn and grass crops. Its eggs are laid on the plants in spring, and the various changes of the insect rapidly go on, the mature form being found about July. The thrips sucks away the juices of the plant and causes the grain to shrivel. They live through the winter under rough clods, etc.

Drain the land thoroughly, as they are found most frequently on marshy ground. Till it well, and remove all weeds. Do not allow any high hedges. Apply gas-lime, and plough the land deeply.

Insects belonging to the Hymenoptera.

Turnip Sawfly (*Athalia spinarum*).—The eggs, which are very numerous, are deposited in small holes cut in the leaf by the ovipositor of the female. They hatch in about a week. The

caterpillars are black, with whitish head, and have numerous feet. In about three weeks they go into the earth, spin a cocoon, and change into the chrysalis. The time in which the insect remains as a chrysalis varies greatly. The flies rapidly devour the leaves of turnips, and cause great damage to the crop.

The grubs should be disturbed as much as possible by dragging branches over the land. The larvæ moult frequently and, if disturbed, they do not succeed in drawing off the old coat, and die. Also they drop from the leaf when shaken, and find difficulty in getting back. As the fly dislikes moisture, it would be well to apply liquid manure or weak solutions of guano or nitrate of soda to the crop.

Gooseberry and Currant Sawfly (*Nematus ribesii*).—The female appears in April, and lays her eggs on the under surface of the leaves. The grubs hatch in a week, and feed on the leaf. After a while, the grub drops to the ground, buries itself, and forms a chrysalis. The fly may come out the same summer or remain until next spring.

Remove the surface soil from under the bushes, and bury it. Then sprinkle a little caustic lime about the roots, and put in some fresh soil. Soot, flowers of sulphur, salt or lime may be given as dry dressings in a fine powder. Washes of soap-suds, containing a little soot or salt, are useful.

Insects belonging to the Lepidoptera.

White Cabbage Butterflies (*Pieris brassicæ, P. rapæ, and P. napi*).—The first is the large white cabbage butterfly, the second is the small white, and the third the green-veined white cabbage butterfly. The eggs are laid in clusters on the under surfaces of leaves, and there the caterpillar is hatched. The caterpillars feed on the leaves of the cabbage crops, until only the veins remain. When full-grown, they go to some quiet spot, hang themselves up by the tail, and change into crysalids. These form the perfect insect in about a fortnight, or else the chrysalis does not come out until next spring. The caterpillars are attacked and often destroyed by small ichneumon flies, which lay their eggs in the backs of the larvæ.

Clean out the winter shelters of the chrysalis. The caterpillars and chrysalids may be hand-picked and destroyed. Sprinkle salt, soot, or lime in a fine powder over the plants. Give washes of solutions of alum. Large amounts of water thrown over the cabbages in the evening cause the leaves to be cold and moist, and in consequence the caterpillars are severely purged and may die.

Diamond-back Moth (*Plutella cruciferarum*).—The eggs are laid in masses, and from these the grubs come in large numbers, soon clearing away the leaves of turnips and rape. The chrysalis has a net-like cocoon, and is found near or on the ground. The summer moths come out in three weeks, those from autumn cocoons in spring.

Give plenty of good stimulating dressings to the crop, nitrate of soda and soot have been much recommended. Soot, applied when the leaves are wet with dew, soon kills the insect. Mr. Fisher Hobbs's dressing for the turnip fly might prove of great use. Pass bushes over the field so as to disturb the pest, and destroy all cruciferous weeds which might favour the attack.

Magpie Moth (*Abraxas grossulariata*).—The female lays the egg or eggs on leaves during summer. The caterpillars appear in August and September, feed a short time, and find some shelter in the ground or among leaves through winter. In the spring they attack the leafage of gooseberry- and currant-bushes. The caterpillar assumes a looped form when walking, and hence is sometimes known as a "looper." The chrysalis, into which the grub turns when full fed, about the end of May, may be found attached to twigs, or in crevices of walls. The moth comes out about midsummer. It is easily recognized by the wings being white with numerous black spots.

Clear away all fallen leaves and the surface soil from about the bushes in early winter, when the bushes should also be well pruned. Hand-pick or shake the bushes, and destroy the caterpillars thus collected. Put a sticky band round the stems. Dust the bushes well with caustic lime.

Codlin Moth (*Carpocapsa pomonella*).—The eggs are laid usually in the eye of the apple. The grub soon hatches and bores its way into the apple, not injuring the core, and makes a hole through the skin near the bottom, through which it passes the rubbish. When full grown, it pierces the core and feeds on the pips, causing the apple to fall. The caterpillar then leaves the apple, ascends some tree, seeks a hole in the bark, spins a cocoon, and forms the chrysalis. The moth comes out the next summer and attacks the apples itself.

All loose bark should be scraped off the trees and burned. The trees should then be washed with a solution of soft soap and mineral oil. No fallen fruit should be allowed to remain on the ground, or the caterpillars may leave it and escape. The remedies for apple-blossom weevil are of use against the codlin moth.

Winter Moth (*Cheimatobia brumata*).—The female, which is nearly wingless, appears in October, climbs up some fruit tree, as apple, pear, cherry, plum, and lays her eggs in crevices of the bark

or on buds. The eggs hatch by next April. The caterpillars feed on the leaves and flowers of the tree, destroying everything they attack, and effectually preventing the formation of any fruit. They change into chrysalids in May, in the ground. The moths come out in autumn.

Place bands of sticky material, as bird-lime or grease, round the trunks of the trees so as to prevent the female climbing up. Prune the trees late, and burn all the prunings, as these may contain the larvæ. Shake the insects off the trees, if possible, and then burn them. Burn the surface soil just under the trees. Give washes of kerosene and soapsuds (made by boiling 1 gallon water and 1 lb. soap, and adding 2 quarts kerosene oil). Sprayings with solutions of Paris-green may be given. The proportions used are 1 oz. to 10 gallons water for plums, and 1 oz. to 20 gallons for apples. The strawsonizer is of great service in applying these mixtures.

Insects belonging to the Diptera.

Hessian Fly (*Cecidomyia destructor*).—The eggs, which are very small and of a reddish colour, are laid near a knot on the straw of some cereal crop or on the stems of couch grass or timothy. The maggot is white and legless, with a very rudimentary mouth, and is produced when the egg is four days old. It lies inside the leaf-sheath, a little above the second knot, and there sucks away the juices of the plant. The larva has a peculiar process just below the mouth, known as the "anchor process," or "cecidomyous appendage," thought to aid in clearing away material in feeding. The attack of the maggot so weakens the straw that it generally bends over, and consequently the head lies on the ground and is much injured, besides being impoverished by the attack. After twenty-eight days, the larva changes into the chrysalis just where it lies. The pupa is a flat brown oval body, resembling flax seed, and sometimes called by that name. The case of the chrysalis is at first smooth, but afterwards becomes much wrinkled. The fly comes out in about three weeks. It is brown in colour, with one pair of grey wings (the other pair being replaced, as in all Diptera, by a pair of knob-like processes or "halteres"). It is $\frac{1}{8}$ inch long, with long legs and antennæ (horns).

Destroy all the light corn obtained when threshing, as it usually contains a large proportion of "flax seeds." It may be either burned or boiled. Sow the autumn wheat as late as possible, as then the flies will probably be dead before the young corn comes up. Infested stubbles should be burned if convenient, or ploughed

so as to turn the furrow slice completely over, and prevent the fly from coming to the surface. In threshing, the straw should be stacked tightly, and not left lying about; the flies are kept in the stack, and die. Use a firm strawed corn which will not readily bend down; and give plenty of good manures to keep it in a healthy condition.

Daddy Longlegs, or Crane Fly (*Tipula oleracea*).—The eggs are laid in autumn on the ground, or on any damp rank herbage near the ground. The eggs are numerous, small, and black. The grubs are 1 to 1½ inches long, and gnaw their way among the roots and stems a little below the surface, causing great damage. The grubs change into the chrysalids a little below the surface of the ground. The flies come out towards the end of the summer, leaving the empty pupa-cases sticking up out of the earth. The fly is noted for its long legs.

As the eggs are chiefly found in damp rank pastures, mowing and burning rough tufts and draining the pastures prevent egg-laying greatly. The land should always be eaten off as bare as possible with sheep. Applications of gas-lime and salt have been of great use. Paring and burning, and deep ploughing, kill many insects. Rolling may destroy the grub in the soil. Guano, nitrate of soda, salt, and superphosphate promote healthy growth.

Carrot Fly (*Psila rosæ*).—The grubs attack the lower part of the root of the carrot, burrowing into it and causing the whole plant to gradually die. The maggot turns into a chrysalis in the earth. The flies come out in a month in summer, but in winter they remain as pupa till next spring. The attack is sometimes known by the name of rust, owing to the colour which the diseased parts turn. On heavy clays the attack is worse than on peaty or sandy soils.

Thoroughly till the land to as great a depth as possible. Thin the crop early, and leave no broken pieces of carrots in the ground. Applications of salt, soot, and paraffin oil are useful. Give a dressing of gas-lime to the land in autumn. It has been recommended to mix a little tar with the soil in autumn, and work it in thoroughly. Give stimulating dressings to the crop. After the carrots have been carted away, plough the land deeply, when many maggots are buried.

Beet or Mangel Fly (*Anthomyia betæ*).—The eggs are laid in patches on the under surface of the leaves. They are very small, white, and oval in shape, with regular hexagonal markings. The maggots feed on the inner tissues of the leaf, causing brownish coloured blisters. After a month the maggots change into chrysalids, either in the leaf, or about 3 inches below the surface of the ground. The flies come out in about a fortnight. The

first brood appears from March to May, and there are one or two later broods.

Give plenty of good artificial dressings, such as superphosphate, guano, and nitrate of soda. Salt is said to check the attack. The infested plants may be pulled out when young and destroyed.

Gout Fly, or Ribbon-footed Corn Fly (*Chlorops tæniopus*).—The eggs are laid inside the sheathing leaves of the young ear of cereals. The maggot attacks the ear, wholly or partly destroying it. The grub then eats its way down the stem to the topmost knot, forming a blackened channel. There it changes into the reddish chrysalis, from which the fly comes out about harvest. The name of "Gout Fly" is given because of the swollen state of the stalk near the ear, which the fly causes. It is thought that the winter is passed by the larva among various kinds of grasses.

Sow the grain as early as possible, as then the plant is strong, and the maggot is not able to move about so readily. Drain the land well, the fly being most prevalent on wet parts. Give dressings ot good manures, as equal parts of guano and superphosphate, to the crop, and thus hurry it on.

Wheat Midge (*Cecidomyia tritici*).—The eggs are laid in the evenings by the female, which deposits them in the young florets. The maggots, which come out in ten days, feed in the ears of the wheat until full grown, when they go down into the earth and change into chrysalids. The flies appear in June and July.

Plough the land in autumn so as to bury as many flies as possible in their winter shelters. Also burn the heaps of chaff obtained in threshing infested grain. Clear away all headlands of grass if possible, especially those of meadow foxtail and couch grass.

Insects belonging to the Homoptera.

Hop Aphis (*Aphis humuli*).—There are two kinds of females of the hop aphis, the wingless oviparous and the winged viviparous forms. The males and wingless females pair in the end of summer, and then numerous eggs are produced. These eggs remain through winter, and in the spring produce the larvæ. These feed on the leaves of the hop. The winged females come out in May and June, and produce several broods of live young. The latter rapidly clear away the leaves of the hops, owing to their immense numbers. They feed by driving their beaks into the leaves, and then sucking up the juices. The leaves in consequence soon shrivel up. The wingless oviparous females come out from these about autumn. It is said that this female passes the winter, if possible, on plum-trees, and there lays its eggs; the viviparous form migrating to the hops in spring.

All pieces of dead hops, or other materials which might shelter the pest, should be removed at once from the field. Mixtures of paraffin oil and ashes, or any disagreeable or caustic substance, as quicklime, gas-lime, soot, etc., when put around the hills on which the hops grow in winter, prevent the plants being attacked by the wingless female and by the larva. Washes of soapsuds, and solutions of quassia, sprayed over the hops by engines, are very useful. Tobacco water and mixtures of soapsuds and mineral oil have been of use when squirted on. The washes should be used on the plum-trees as well as on the hops.

Ladybirds (*Coccinella*) feed voraciously on aphides, and they and their larva should be protected.

Bean Aphis (*Aphis rumicis*).—The wingless females produce living young, generally at the tops of the beanstalks. These also produce living young, and thus the breeding goes on, enormous numbers of the aphis being produced. They are black in colour (hence their names of "Collier," and "Black Dolphin.") They suck away the juices of the plant, puncturing the epidermis and causing the plant to be in a very dirty sticky state. There are three kinds of females; the winged and wingless, producing living young, and the wingless oviparous female. The latter lays her eggs in autumn, and new generations start from them in spring.

The tops of the shoots, as soon as infested, should be clipped off with all the insects on, and immediately destroyed. Dressings of soot are of great use, as are also washings of soapsuds and paraffin oil well mixed. These stick to the aphis and prevent them breathing, which is otherwise carried on by means of tracheæ (openings) in the sides of the insect. Keep up a good growth with dressings of superphosphate, etc.

Plum Aphis (*Aphis pruni*).—There are three kinds of females, similar to those of the bean aphis. The two viviparous females produce numerous broods of young throughout the summer. The oviparous female begins in November to lay its eggs. The insects excrete substances injurious to the health of the plant. They obtain their food from the leaves by their suckers, causing the leaf to roll up, and living inside the roll.

Give washes of a solution of soft-soap, or of soap and paraffin oil. The following mixture has been found useful: 10 gallons water, 20 oz. each of quassia and soft-soap, 1 oz. Paris green; the whole well boiled.

Turnip Aphis (*Aphis rapæ*).—The life history is similar to those of other aphides. They attack the under surfaces of the leaves of swedes, turnips, and sometimes potatoes.

Various washes, especially when distributed by the strawsonizer,

are very useful. They chiefly consist of soft soap, tobacco, quassia chips, or mineral oil. Twenty-eight pounds of soap, and 1 lb. tobacco, per 100 gallons water, or $\frac{1}{2}$ gill paraffin oil per gallon ot water, may be used.

Corn Aphis (*Aphis granaria*).—The insects attack cereal crops, driving their beaks into the stems and leaves, and sucking up their juices. Afterwards they attack the ears, and feed on this part until, as it gets older, it hardens and prevents them piercing it with their beaks.

Sow the seed early, as then the grain will be more mature before the attack begins. Clear away all graminaceous weeds, and apply dressings of fine lime and soot.

(*b*) Other Small Animal Pests.

Stem Eelworm (*Tylenchus devastatrix*).—These small nematoid worms belong to the Scolecida. They got their name of eelworm from their long slender form. They have a spear-like process in their mouth-cavity, and the alimentary canal runs right through the body. They are produced in large numbers from eggs. The worms attack the stems and flowers of clovers, causing clover sickness, and also the lower parts of the stems of oats, causing tulip-root, or segging.

Do not grow clover or oats on the same land for many years after the attack. Skim-ploughing, thoroughly done, will bury numbers of worms. A mixture of sulphate of potash 3 cwts., and sulphate of ammonia 1 cwt. per acre is of use, as is also 2 cwts. sulphate of iron.

Ear-cockles (*Tylenchus tritici*).—Belong to the same genus as the last. The small worms attack the grain of wheat, and may be found in large numbers there. They cause the grains to become large, and of a purplish colour, and to appear filled with a dense cotton-like mass.

As the affected grains are lighter than others, they can be separated by throwing the seed into water, and skimming off those which float on the surface. Do not, if possible, allow any of the infested grain to remain in the field or be returned in the manure. Steep the grain before sowing in a solution of copper sulphate (1 lb. to 4 bushels seed).

Millepedes (*Julus* and *Polydesmus*).—These belong to the sub-kingdom Myriapoda. They have a worm-like form with numerous legs. The eggs are laid through winter in the ground, or amongst dead leaves or other rubbish. The millepedes feed on vegetable matter, and often attack mangels, and the roots and stems of many other plants. Centipedes, which closely resemble millepedes,

are animal feeders, and are useful in destroying many small insects and grubs.

Clear away all rubbish heaps, and skim plough the field, so as to bury the pest. Solutions of salt or nitrate of soda kill the millepedes.

Slugs (*Limax* and *Arion*). Belong to the order Mollusca. They lay their eggs in the ground. They attack many kinds of plants, chiefly in gardens.

Give repeated dressings of salt, quick-lime, gas-lime, or soot.

PART II.—AGRICULTURAL PRACTICE.

CHAPTER I.

MECHANICAL IMPROVEMENTS OF THE SOIL.

Tillage Operations.

Before we enter into the details of tillage operations, there are certain preliminary matters to be considered. It is particularly important that the cost of the different kinds of work be known, and, in order to arrive at a definite conclusion, the price of horse labour must first be reckoned. On p. 428 will be found an example showing the cost of keeping a Clydesdale. The amount is about £29 per year.

Taking the number of days on which light land can be worked as 290, and the number on which employment can be found on heavy clays at 250, we find that on the former the daily cost of horse-labour is 2*s.*, and on the other about 2*s.* 4*d.* On stiff clays, two horses will work sixty acres, equalling thirty acres each. From this the cost of horse-power per acre would be nearly £1.

Cost of Tillage Operations.—We have just seen that horse-labour costs about 2*s.* 6*d.* per day. A man often receives the same amount, though in harvest time his wages may be doubled. A boy earns about half as much as a man; a woman gets a little more than a boy. From these prices the cost of nearly any agricultural work may be readily reckoned out, if the number of labourers and horses and the time required for a certain amount of work are known. We give the costs of the more common tillage operations later on.

Fallowing.—The theory of bare fallows is given on p. 302, and the practical details of the operation will now be noted.

The work commences immediately after harvest, the stubbles being ploughed up in September or October, if possible. When

many autumn-sown crops are grown, the farmer will not be able to do this. The land is left in the rough state through winter. Early in spring another ploughing is given across the old furrows; and then two or three harrowings to draw out the weeds, which are collected with the chain-harrow and destroyed. Three or four more ploughings are afterwards given at intervals of from one to two months, finishing in August. During the summer the land is harrowed as many times as possible, as many as a dozen harrowings and draggings being often given. With the roasting effects of the sun acting in the favour of the farmer, there will not be many weeds left after such a course of operations. Previous to the final ploughing, a dressing of ten to fifteen tons of farm-yard manure or compost is given, and then covered in with the plough. In some parts of England it is the custom to fold sheep upon the bare fallows. They are kept within hurdles or nets, and green fodder, such as vetches, is brought to them daily. Sometimes they receive concentrated food in addition. As soon as one plot is sufficiently manured, the hurdles are shifted on to a fresh break.

After a bare fallow, wheat is nearly always taken. It is sown in October, and does not usually require any further preparatory cultivation.

Cost of Bare Fallows.

	£	s.	d.
Five ploughings, at 7*s*. 6*d*.	1	17	6
Four drag-harrowings, at 1*s*. 6*d*.	0	6	0
Seven harrowings, at 6*d*.	0	3	6
One rolling, at 1*s*.	0	1	0
Collecting weeds	0	3	0
Filling, carting, and spreading dung	0	7	6
Water furrowing	0	1	6
Rents, rates, etc.	1	15	0
Cost per acre	£4	15	0

Autumn Cultivation.

The benefits derived from autumn cultivation are numerous and well-known. At no better time of the year can the soil be exposed to the action of the natural atmospheric agents. The rains and frosts of winter crumble down the clods and produce the best tilths. Oxidation is enabled to go on for several months together, and hence the reason why trench-ploughing is best done in autumn. Again, just after harvest the soil is in a mellow condition, and weeds are somewhat weak through having been

overshadowed for such a long time by the corn crop. Work is rather slack just then, and these three conditions make autumn cultivation highly commendable to the farmer. More especially on the stiff clays is this so. In the spring, the periods during which they can be tilled with advantage are often few and far between, and the farmer who has got his land cleaned and well worked previously, can get on with his seeding early.

The processes of autumn cultivation have already been indicated to some extent when treating of the preparation of the land for roots in the "Elementary Text-book." Should thorough tillage be needed, as when the fields are very weedy, the operations are more numerous. For example, on light soils after ploughing, which is most effectually done by the chill plough, the land is harrowed, the drag harrows or scufflers being used. This breaks up the furrows and tears out the weeds, which may then be collected with the lighter harrows. They are burned, and a rolling is next given, followed by another harrowing. All these operations cannot often be done in autumn on account of other work; a ploughing and harrowing are all the land sometimes gets. Should there be time to spare after doing this, the operations may commence again and finish up with a deep winter furrow being given.

On heavy land steam cultivation is more suitable. A thoroughly good smashing up should be given early in autumn, or horse labour may be employed in a somewhat similar manner to the preceding case.

I. Ordinary Tillage Operations.

Enough has already been said upon the scientific side of tillage in the "Elementary Text-book on Agriculture," and at present we will deal more with the actual operations.

The ordinary tillage operations will be first considered.

Ploughing involves the inversion of the soil by means of the mould-board. The process is begun by the coulter, which divides the furrow-slice from the land. The sock or share then separates it below and raises the furrow-slice on to the mould-board, which turns it over and lays it on one side.

In order that the operation may be more easily performed, land is ploughed into ridges, separated one from another by an open trench, which has been formed by throwing the soil up on both sides. The widths of these ridges vary; on heavy lands they are narrower than on light. The open trenches also provide for surface drainage. In Scotland they are, as a rule, broader than in England. On clay soils the ridges may be as narrow as

seven feet, and fourteen or sixteen feet is a common distance. On light soil in Scotland eighteen feet is the usual width; but in drier climates they may be up to thirty-three feet. The ridges usually run from north to south, to get a full exposure of the crop to the sun.

The first process when the land has to be raised into ridges from the flat is known as "feering." The headland is marked with a furrow by the plough, and then from one side of the field a straight line is set off about a quarter the width of the ridge away. From this line all others are now measured off. A line (which we may call A) is set off 1¼ ridges away, and another (B) a quarter ridge off. The space between the two is divided at C. A and B form the crowns of two ridges, and C an open furrow between them. Ploughing commences by first throwing together two furrow-slices at B, and then working round and round them until the ridge is finished. From A another ridge is set out and divided into equal parts at D. The ridge C to D is now ploughed out, and so the work proceeds.

Another quicker method, suitable for light soils and dry climates, is the "two-out-and-two-in" plan. The first line (call it A) set out is one ridge breadth (5 or 5½ yards) from the hedge, and forms the ridge of a land. From A, three times this distance is stepped out to B, and the interval between A and B divided into three equal parts, by the lines C and D. Ploughing is commenced around the line A, and, when finished, another distance of two ridges is measured from B, and the land between B and the fresh line is ridged up around a crown furrow as before. The interval between C and B is now ploughed, but in a different direction to the others. When at work on the two previous pieces, the centre line was always on the right hand, and the furrow slices were consequently thrown in towards it. Now the position is reversed, and the line D thus becomes an open furrow. After this has been done, another is measured out as before. In this manner it will be seen that the distance between two open furrows is as wide as four ridges.

Among the points to be attended to in ploughing are (1) a straight furrow, of uniform depth and width; (2) furrow slice clean, free from ragged edges; (3) furrow slices not pressed hard together; but all laid evenly, and none with higher crests than others; (4) all vegetation to be completely covered; (5) the ridges should be of equal size from the crown to the furrow on both sides; (6) the open furrows should be regular.

The forms of furrow-slice vary according to the character of the plough. Among them may be taken—

1. The *crested*, or *trapezoidal*.—This is objectionable, as it

leaves some soil unmoved in the bottom of the furrow, is not firm, and allows the seed a greater chance of falling through. It is narrow, and hence is a slower method. The advantages are

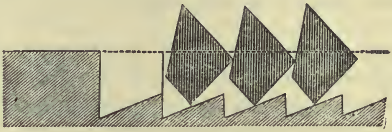


FIG. 33.

that it harrows down and covers the seed well, and has less open space below.

2. The *rectangular* furrow-slice.—It does not harrow down so easily, and plough-irons are not usually made to set to it. It is,

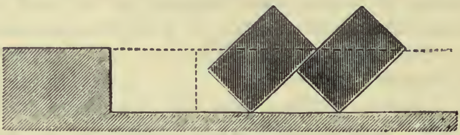


FIG. 34.

however, better in most respects than the last. The furrow-slice lies at an angle of 45°, and the proportion of depth to breadth is as seven to ten.

3. The *parallelogrammatic* furrow-slice.—This is the best form

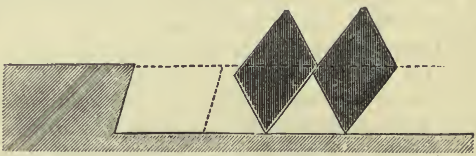


FIG. 35.

of the three. It is proportionately wide; and plough-irons are easily set to it. No soil is left unmoved in the bottom of the furrows; it is firm, crested, and harrows down well.

4. The *wide, flat* furrow-slice.—In this case the furrow-slice is

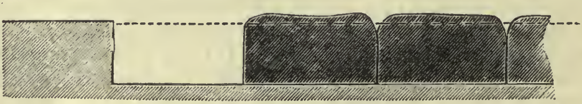


FIG. 36.

turned completely over, and buries any vegetation. It is made by the short mould-boards of the chill-plough. It is very suitable for

light lands, as there a large amount of ground can be covered in a day, and the soil gets well pulverized.

Size of Furrow-slice.—An ordinary furrow-slice is ten inches wide by six inches deep.

Amount done.—From $\frac{3}{4}$ to $1\frac{1}{4}$ acres can be done by horse-power in a day of ten hours. On stiff clays the work is very hard from the soil sticking to the plough, and then three or even four horses may be required. On stubble land most can be ploughed. The average pace of the horses is $1\frac{1}{2}$ to 2 miles per hour, and, with a ten-inch furrow, they walk a little less than ten miles per acre. A considerable time is always lost in turning, besides rests and other delays. The cost of ploughing may be taken at 7*s.* 6*d.* to 10*s.* per acre.

Raftering, or half-ploughing, somewhat resembles the work done by the chill-plough. It is sometimes undertaken when the land is to undergo paring and burning. The land is ploughed to a depth of one to three inches, a special form of sock being used. The furrow-slices are wide and are made to fall upon the land, so that alternate strips only are dug out. Thus, in the

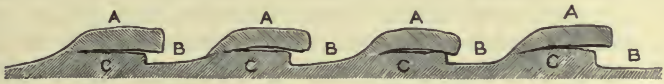


FIG. 37.

diagram, the furrow-slice A is dug out of B and spread over C, the weeds being thus caught between A and C.

Double-mouldboard Ploughing is practised when drills are raised or split. The soil must be in a fine state, and it is then thrown up equally on both sides by the two mould-boards.

Harrowing is usually performed with a view either to render the surface soil fine or to cover in seed. Chain harrows are also used for collecting weeds and levelling the surface in arable cultivation, and for working in composts, etc., on pastures. The heavy drag-harrows break down clods and do the rougher work. Seed-harrows level the surface and cover in seeds. For the latter purpose they first pass along the furrows, and then across them, and may sometimes pass along again. It is a good plan to harrow corn in spring.

The amount harrowed in a day will vary according to the kind of implement and the soil. A two-horse harrow, covering $7\frac{1}{2}$ feet, will get over eleven or twelve acres per day, giving a single turn. Harrows very often cover more than this, and with one ten feet wide fifteen acres per day may be finished.

For the light harrows 6*d.* to 9*d.* per acre may be charged

for a single turn; but for drag-harrowing the cost is usually doubled.

Grubbing or Cultivating.—By means of the cultivator the soil is stirred without being brought to the surface. A depth of four to six inches can thus be tilled. For spring work it is very useful, and especially so when preparing for turnips or mangels. The object then to be attained is to get a fine tilth without favouring the evaporation of water, and this is certainly better accomplished by the grubber than by the plough. This implement is also very useful in drawing out long-rooted weeds like couch, though it is apt to pass those with tap roots.

While two horses only are needed to work the cultivator on light land, three or even four may be required where the soil is stiffer.

Two horses with a five-tine grubber on light land will cultivate five acres per day to a depth of six inches. On a stiff clay a three or four-horse cultivator will do an acre more at the same depth.

The cost per acre varies from 2*s*. to 4*s*. on the heaviest soils.

Rolling has many uses: (1) it breaks down clods and procures a fine tilth; (2) it consolidates light soils, pressing their particles into closer relation with the roots of the crops; (3) it presses the soil more firmly around newly sown seeds, and, before they are drilled, a fine level seed-bed can be obtained which favours the regular distribution of the seed. For pulverizing clods, the croskill roller is most suitable.

Autumn wheat usually receives a rolling in spring, and thus any plants thrown out of the ground by frosts have the roots covered again. This is very important work, and should be done whenever possible.

Rolling light land consolidates it to some extent and gives the crop a better chance of growing. Grass land thrives better after a good rolling given in rather wet weather. The operation, on stiff land especially, must be done when the soil is dry, or a hard condition of the surface soil results.

One horse, with a light roller, five feet wide, will finish six acres per day; a two-horse roller, six feet wide, will do eight or nine acres on fallow land, ten acres on a seed-bed for corn, and twelve or thirteen acres on grass land. The cost per acre will consequently vary greatly; in the easiest cases it will not be much more than 4*d*., but the price may rise to 1*s*.

Digging by manual labour is seldom carried out now on account of the slow progress made and the consequent expense. It is of use (1) when thorough cultivation is needed, and (2) where a certain part requires special cultivation. For the growth of teazles, for instance, spade husbandry is necessary; but the acreage under this crop is insignificant. To dig with a spade an

acre of land to a depth of nine to twelve inches will take a man from fourteen to twenty-one days in recently moved soil. If old lea, it will in some cases take double that time. The cost of this, taking a man's wages at 2*s.* 6*d.* per day, is easily reckoned out, and is seen to be more than the value of the benefit obtained.

Hoeing is done for two purposes: (1) weeds are kept down, (2) the surface soil is stirred and loosened. Both of these points assist the better growth of the crop, which must, of course, be drilled. A horse-hoe, doing ten or twelve acres corn land per day, costs 7*d.* per acre. A scuffler or simple drill hoe finishes about five acres of roots or beans at a cost of 1*s.* 3*d.* per acre. Hand-hoeing is performed at the rate of half an acre per day on fairly clean land; this gives the cost at 5*s.* or 6*s.* per acre. On very foul land only a quarter of an acre per day may be hoed, thus costing 8*s.* or 10*s.* per acre.

Steam Cultivation.

Steam power seemed at one time likely to a great extent to supersede horse labour on the farm, but practical difficulties have been found which often will not allow its use. Steam cultivation is at its maximum value on the stiff clays. The evil effects of the treading by horses are avoided, and the chances of forming indurated pans are lessened. The steam tackle can be put on the stubbles soon after harvest, and the land thoroughly smashed up in a short time. At that period the land is best able to carry any weight, and the comparative rapidity with which steam cultivation can be carried out gives to most of the fields the benefits of autumn cultivation. The tillage can be made deeper and more efficient than by horse power, and the cost per acre is reduced. When the land is in a fit state, its cultivation can be got on with more rapidly. This is a great advantage on clays, on which there are often only short intervals during which they are fit to be worked. Steam implements enable the farmer to reduce his staff of horses, and, as the rest will be relieved of the hardest work, they can be kept at less cost. Steam ploughs, etc., it must be remembered, do not cost anything more for keeping, when not working, than the actual interest on the primary outlay. Horses, however, require to be fed, whether they work or not. The engine can also often be used for other purposes, such as threshing, grinding, chaffing, etc., when not engaged in tillage work.

Among the drawbacks to steam cultivation are:—

(1) The area of usage is limited by the nature of the ground and size of the fields. Hilly surfaces, and small irregularly shaped fields, are not suitable.

(2) The primary outlay is considerable, and might be too

much for a small farmer, who would have to hire the tackle or join with others in the purchase.

(3) Considerable time is taken up in removing from one field to another, much more so than with horse cultivation.

(4) A certain amount of injury to the headlands and gate-posts is often caused.

Systems.—There are two chief systems of steam-cultivation, viz. the single and double engine methods.

The latter plan is most suitable for large farms. The tackle is more easily removed and set to work, and nearly twice as much work can be done. Two engines are simply placed on opposite sides of the field. Each engine has a winding drum underneath the boiler, worked by bevelled gearing from a crank-

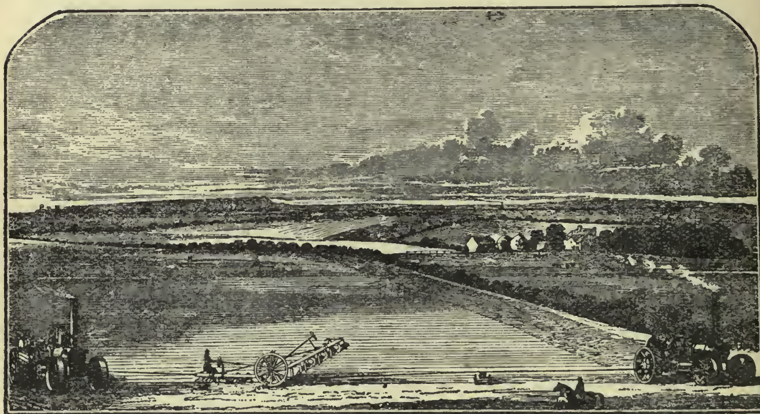


FIG. 38.

shaft. The drums have about four hundred yards of steel wire each, which is also fastened to the plough. The arrangement may be seen in the figure. The procedure is very simple. The two engines at the ends of the furrows alternately draw the plough or other implement, guided by a man, toward them. While one is pulling in this manner, the other moves forward a little, so as to be ready to form a fresh series of furrows.

The single-engine system may be again divided into two plans. In one, the implements are worked by ropes from an engine having double drums mounted upon itself; in the other, the rope proceeds from a portable windlass, carrying two drums, which are driven by a pitch-chain from the crank-shaft of an ordinary traction engine. In either case it is not necessary for the engine to move while

working, and it can therefore be placed on any convenient part of the headland.

There is some tackle needed in the single-engine method, which is dispensed with in the other. More steel rope is required, and the plough runs between two self-moving "anchors." These consist of a strong iron or wooden frame on four disc-wheels, and carrying a strong guide-pulley. From the drums near the engine the two ropes pass separately over guide-blocks, and thence round the anchors to the plough or other implement.

The implement is worked backwards and forwards by alternately winding up the rope on one drum, and then allowing it to run out while that on the other drum is drawn in. The anchors are self-moving, and shift their position nearer to the engine when the plough gets to them. The guide-blocks between those at the corners and the anchors need to be moved by hand as required.

Cost of Tackle.—

DOUBLE-ENGINE SYSTEM (FOWLER).

	Single cylinder.		Double cylinder.	
	6 horse-power.	12 horse-power.	6 horse-power.	12 horse-power.
	£	£	£	£
Two engines ...	1065 0 0	1330 0 0	1200 0 0	1500 0 0
900 yards wire rope	74 5 0	94 10 0	74 5 0	94 10 0
	1139 5 0	1424 10 0	1274 5 0	1594 10 0

SINGLE-ENGINE SYSTEM (FOWLER).

	Single cylinder. 12 horse-power.	Compound cylinder. 12 horse-power.
	£	£
One engine	885	965
1200 yards steel rope	68	68
Self-moving anchor	66	66
Three special and three small rope porters	18	18
Claw-anchors and snatch-blocks ...	20	20
Extra self-moving anchor and rope, required when working with engine stationary	90	90
	£1147	£1227

	£
4-furrow balance plough	102
Turning cultivator, 7 tines	85
„ harrow, 15 ft. wid	97

Work done by Steam Implements.

The steam-ploughs and cultivators are the implements most generally used. Both are made to extend over considerably more ground than the ordinary forms, and break up the soil more thoroughly and to a greater depth. The cultivator, especially, is a very useful machine. The steam digger has been brought forward prominently lately. It is a very effective means of smashing up the land, and differs from other steam implements in the fact that the single engine needed has the working parts directly attached to it, and consequently has to travel across the land.

Steam cultivation is particularly suited for the autumn, but can be used at other times with advantage. About eight acres are ploughed per day by the double-engine system, this being at the rate of two acres per furrow. When hired, the charge per acre will be about fourteen shillings; but where the farmer has his own tackle, it need not cost him more than eight or nine shillings. In grubbing, nine inches deep, from six to ten acres are done per day, according to the system followed. Thirty acres of land can be harrowed per day by steam, and about ten acres may be dug up to a depth of eight inches. Twenty acres may be drilled per day.

2. Occasional Tillage Operations.

Besides the ordinary tillage operations which have just been described, there are several other mechanical means of increasing the fertility of the land which are not so common, and do not require to be performed annually.

Subsoil Ploughing.

The object of subsoil ploughing is to deepen that section of the soil in which plants will be able to grow. The ground is stirred and loosened, air is admitted freely, and drainage is facilitated. Every extra inch in depth means an enormous increase in the plant-food resources of the soil. Those hardened layers of the soil known as *pans* are broken up, and the free percolation of water thus assisted.

Mr. Smith of Deanstone recommended that the subsoil plough be never used until at least a year after drainage. This allowed the subsoil time to get into a fairly dry condition. Many failures in subsoiling have arisen through working the subsoil when too wet. Among farmers employing steam cultivation the operation

is commonly known as *knifing*, from the strong steel coulter, or knife, with which it is performed.

Subsoiling is either done by horse or steam power; but, as it is very hard work, the latter method is preferable, where it can be carried out. All that is needed in this case is to fix a deep, strong, curved coulter to each plough-frame. The horse implements, in their simplest form, consist of an iron beam, as in the ordinary ploughs, but rather stronger, with a strong wrought-iron body attached, but with no mouldboard. The land is first ploughed deeply, say to ten or twelve inches, with the common plough. The work is hard, and three or four horses will be needed. Then the subsoiler follows, breaking up the land to a total depth of about two feet. For this purpose from four to eight horses will be required. An improved form of the subsoiler has a strong subsoiling coulter in front, breaking up the land. Farther back and to the left is a mouldboard, which thus throws a furrow-slice over the subsoiled portion, and prevents consolidation by the treading of the horses.

The land is broken up most thoroughly by steam cultivation, a depth of three feet being then obtainable.

Subsoiling gives the best results on light soils, especially when pans are present. When the operation is once done, the beneficial effects are visible for a long time after. On stiff clays the tendency of the land is to soon close together again, and in a few years very few traces will be left. The operation in such cases is also a very expensive one, and hence is not likely to commend itself to farmers there. For the first few years good results would be obtained from the breaking up of any indurated pans, but the effects are only temporary.

The best time for subsoiling is in autumn, as soon after harvest as possible. It is usually done on the corn stubble, before roots.

Trench-ploughing.

This operation differs from subsoil ploughing in the fact that the subsoil is here brought to the surface. It is highly critical, and only on deep rich soils can it be advantageously performed. Where the subsoil is of poor composition, it will be easily seen that the supply of plant-food in the soil will be diluted, and poorer crops result. Again, injurious compounds (such as the lower oxides of iron and sulphides) may be brought up, and utter barrenness result for a time. Of course, in this case, exposure to the air would oxidize and neutralize these bodies; but during the intervening period the produce would only be small. A third objection against trench-ploughing is that it often

brings up an extraordinary crop of weeds, especially charlock. The seeds of this troublesome plant are small, round, heavy, and oily, and, being ripened in the middle of summer, they often fall down the cracks which may then abound in the soil. Their oleaginous nature prevents their decay for a long time, and hence, when they are again brought to the surface, as by trench-ploughing, they begin to grow luxuriantly.

From these considerations it will be seen that great care must be taken in trench-ploughing. Of course, on soil of good depth and composition, such as alluvium, considerable benefit will be derived from bringing a rich subsoil up to mix with a more or less exhausted surface soil. Also, the latter may be deficient in some constituent, such as lime; while the subsoil may be calcareous. In that case good results might be expected from the operation.

The trench-plough may be somewhat similar to the one used for subsoiling, but has an inclined tail-board at the back, up which the earth is forced, and spread on the surface.

The best method of deepening the soil is to do it gradually, not at one operation by the trench-plough. Every autumn, before a fallow, the land should be ploughed an inch or two deeper than usual. A little fresh soil is brought up and incorporated with that on the surface. It is exposed to the atmosphere all through winter, and any injurious substances it contains thus get thoroughly oxidized. This plan will require plenty of time, but it gives much better results in the end.

Clay-burning.

This involves the incineration of the surface soil to a depth of several inches. The land is broken up through summer, commencing in May or June, by a strong plough, requiring three or four horses. This work must only be done in dry weather. The clay is then brought into heaps, scattered at wide intervals over the land. A nucleus is first made of brushwood, roots of trees, slack coal, or any other suitable fuel. The clay is built around this, and the fire then lighted. At first the pieces are lifted on by hand, but as the heat permeates the mass, it is wheeled on in barrows. Fresh coal is gradually added, and then more clay, until the heap contains as much as two hundred cubic yards of material. These large heaps are commonly known as "clamps." The walls are built of the larger pieces, and the small clods are used in filling up the interstices.

Considerable skill and care are needed to get good results. The fires require to be watched day and night, and must not on

any account be allowed to burst through the walls of the clamp. All weak places are covered with fine soil applied with a shovel, and in order that the flames may not be fanned by the breezes, thatched hurdles are often erected around each heap. Slow combustion is to be aimed at, and a uniform spreading of the heat through the mass. Should the combustion be rapid, red clinking brick-like masses are the result, instead of being black and crumbling as desired. On the other hand, the fire must not be allowed to die out before the operation is complete, as very great difficulty will be experienced in relighting it.

When the clay is burned enough, the fire is gradually extinguished by preventing the access of air as much as possible. The heaps stand some time, until they lose their heat, and are then carted away and spread over the land. From forty to fifty cubic yards per acre is a common dressing. The cost of the operation varies. The instance given is by Mr. C. Randall in *Journal V. of the Royal Agricultural Society.* He says that two or three tons of raked slack (coals), costing nine shillings per ton, will burn in fine weather more than one hundred cubic yards per acre, in heaps of about a cartload each. The cost was as follows :—

	£	s.	d
Labour of burning 100 cubic yards per acre, at 6*d*. ..	2	10	0
Two tons of coal, at 9*s*.	0	18	0
Wheeling and spreading a distance of 50 yards from the heap, and filling and spreading the remainder, 100 yards, at 1½*d*.	0	12	6
Per acre	£4	0	6

One hundred cubic yards is, however, rather a heavy dressing, and where the fuel used is waste wood, he estimates the cost at forty-one to fifty shillings per acre. Brushwood, he says, is better than coal, as it heats the mass more gradually. After clay-burning, Mr. Randall recommends as a rotation—(1) wheat; (2) clover (mown), and mixed seeds (grazed); (3) wheat; (4) half beans, half fallow crop, reversing their position each rotation.

Clay-burning acts (1) mechanically, and (2) chemically.

(1) The soil burned is rendered very friable, and, when ploughed in, to a great extent counteracts the tenacity of the clay.

(2) The amount of soluble salts is increased, the increase being principally in oxides of potash, soda, and iron. If the soil be calcareous, the phosphates will be rendered more available by the complete disintegration which attends the conversion into lime. The lime will also attack the silicates of potash in the soil, and a part will be liberated in a soluble form. To secure the last two advantages, lime should be mixed with the heaps when

not present naturally. On the other hand, the amount of available phosphoric acid is slightly lessened. Dr. Voelcker, however, found that when much wood, etc., was used as fuel, the amount thus obtained quite counterbalanced any that was lost. The great objection against clay-burning is the dissipation of nitrogen, owing to the combustion of the organic matter. The other beneficial effects are, however, a good set-off against this. When the clay-burning proceeds too rapidly, the results are not very good. The mechanical condition is not improved, and this is one of the greatest benefits when the process is properly carried out.

Paring and Burning.

This is not such an expensive or permanent operation as the last, and is undertaken simply to clear the land of weeds and accompanying pests.

The work is commenced about March, as the land is cut more easily then than later on. Boggy land should, however, be dry, so as to give a better footing. The surface soil to a depth of two or three inches is taken off by a paring plough, the process of raftering being very suitable here. The American chill-plough may be used. The old method was to pare it off with a "flauchter spade." This consisted of a special cutting spade, with a broad horizontal T-handle, which was pushed along by the thighs. It was a very slow plan, about a week being taken for each acre.

After separating the sods from the ground, they are set up on their edges against one another to dry. This occupies at least a fortnight. The process of burning is then conducted in a similar manner to clay-burning. As a large amount of vegetable matter is present, very little fuel is needed.

About the Cotswolds the method varies somewhat from the previous. The work is undertaken after a corn or clover crop, and commences in this case in autumn. The land is shallow-ploughed, and then harrowed and rolled to reduce the size of the clods. The loose weedy soil is now raked together, either by horse or hand rakes, being collected into numerous small heaps. It is lighted by means of wisps of straw, and then the small clods are put on, and the heap increased to its proper size.

After allowing the mass to cool, the ashes are spread over the land, but should not be ploughed in just then. Turnips are often taken after paring and burning, and a good crop is usually obtained.

Paring and burning is generally undertaken to get rid of all weeds. This it speedily does, as well as all insect pests. For this reason it may be undertaken with advantage when breaking up old sainfoin. The effects on the land are much the same as

with clay-burning; but as more organic matter is present, there will be a greater loss of nitrogen. This is a very serious objection in many cases, but where it is only undertaken to get rid of rubbish it fulfils its purpose most thoroughly.

About the Cotswolds particularly the process goes under the name of stifle- or close-burning. The cost may amount to two pounds per acre.

Claying.

Many soils are naturally so light and sandy that their texture has been found to be greatly improved by the application of clay or marl to them. The reverse process has not been attended with such good results, and hence the common saying that a small amount of clay will go a long way with sand, but will itself swallow up any amount of the latter.

The work should begin in autumn, so that the winter frosts may crumble any clods. Sometimes the clay has to be carted from pits some distance away, in other cases it forms the subsoil. The peats of Lincolnshire, for instance, rest upon the Oxford clay, and in many cases trenches have been opened down to clay, which is then dug up. The material is then spread over the surface at the rate of from forty to one hundred cartloads per acre. The distance between the lines of trenches varies from eight yards, which is about the minimum, to twenty.

It is not usual to dig a long trench; pits have been found to be better, as they are more easily filled up again. These pits are from three to four yards wide, and six to nine feet long. Two or three spits' depth of clay is dug out of each, and thrown upon the sides.

The effects of claying are almost entirely mechanical, but the fresh soil applied to some extent affects the composition.

The cost varies from £2 10*s.* to £5 per acre. The expense becomes too great for the operation to be profitable when the carriage is for a long distance.

Mixing Soils.

The benefit of mixing soils is readily seen where the edges of two or more formations mingle, or on alluvial land. There, as a rule, the soil is of higher quality than either of the originals. Many instances of this may be seen in the geology of England. Some of our best land is found where the lower chalk joins the upper greensand, and where the London clay meets the chalk much benefit is derived from the improved mechanical condition.

Marling, chalking, and other forms of mixing are conducted

in the same way as claying. Chalk should always be spread over the land in autumn, or just at the commencement of winter. The frost then has time to crumble down the pieces.

There is another process of mixing which may profitably occupy a little of the spare time through winter. This consists in carting on to bare hillsides soil from the hollows, into which it has been washed. The land is thus covered all over with a reasonable depth of soil.

CHAPTER II.

FARM CROPS AND THEIR CULTIVATION.

A.—*Rotations of Crops.*

A ROTATION is simply a systematic plan of growing crops extending over several years. It is very interesting to see how such methods have arisen. The old nomadic tribes simply grazed the land till it was too bare, then they moved on to pastures new. As the people became more civilized, the land was divided up into plots, and crops were taken just as the owner desired. Grain was chiefly grown, and it was found that, after a certain number of years, sufficient return was not obtained. The fields were left idle (fallowed) till they had recovered, when they were again broken up. Such a plan meant a great deal of irregularity in the farming, and it was found best to take a fallow at fixed intervals. In order to provide a proper food supply, certain crops were regularly taken, and thus the old three-course rotation employed by the ancient Teutonic tribes was evolved. They divided their land up into three parts, on one of which was grown winter grain (wheat); on another, summer grain (beans, oats, barley), while the remaining portion was fallow. The rotation thus was Fallow; Wheat; Beans, barley, or oats. This method is even carried out now on certain very stiff soils. It was, however, found to give little variety, and it was essentially unsuited for stock farming. Hence alterations were gradually made, and more fodder crops inserted; but nearly all existing rotations can be traced back to the old three-course.

Advantages of Rotations.—1. One ingredient of the soil is not drawn upon to an undue extent, as no two similarly feeding crops are taken together. Turnips remove five times as much potash per acre as wheat; hence, if they were grown several years in succession and sold off the farm, that constituent would become

much exhausted. Besides requiring different food, plants do not all search for it in the same layers of the soil. Some with their deep roots can descend into the subsoil, while others are only surface-feeders. Among the former are wheat, rye, mangels, rape, red clover, lucerne, and sainfoin; while with the latter are ranked barley, turnips and swedes, white clover, and potatoes. Again, some crops require their food to be in a readily available condition. Turnips, for example, have little power of absorbing the combined phosphates of the soil, and consequently they remove most of that already soluble.

2. Less manure need be applied to the land to produce the same crop. There will be more natural plant-food in the soil to be used. This, of course, means less expense, and consequently a larger profit on the arable land.

3. During a good rotation the land gets thoroughly cleaned. Contrast, for instance, the continuous growing of a wheat crop and the growth of a root crop in a rotation. All through the summer the land cannot be touched in the former case; weeds spring up and bear seed to be scattered all around. In the other instance, not only is the land kept bare until, at least, late in spring, but it is kept clear of unnecessary vegetation through its whole period of growth. The cleaning effects will be felt through the entire course. Every rotation contains either a bare fallow or some fallow crop, as turnips, swedes, mangels, etc., which are generally grown in rows so as to allow various suitable implements to be worked over the land when the plants are above the ground. Absence of weeds allows greater freedom in growth of the crop, and also fertilizing ingredients are put to their proper use.

4. The labour of the farm is more evenly divided over the whole year. Suppose, for example, that a farmer is solely employed in growing cereal crops. He certainly may get a large proportion, if not the whole, of his wheat sown in autumn; but it would be very hard work to get his crops all in, and the land thoroughly tilled before October. Then his spring corn would be sown nearly all together. But the chief difficulty would be at harvest time. With all his crops ripening nearly together, a large number of men, horses, and machines would have to be kept. In a rotation, in the first place, less corn would be grown. Then, again, there would be other crops cultivated, and with these the labourers could be profitably employed at other periods of the year. Fewer men and horses will be needed, and the expenses consequently kept down.

5. There is a continuous supply of food for the stock, as well as of crops (such as grain) to be sold. Every year there is a

large proportion of roots and fodder crops to be eaten by the farm animals, as well as of grain, potatoes, etc., for the markets. In the simplest forms of rotations, such as the Norfolk, we get Fallow-crop, corn, fodder, corn. The first and third are for home consumption, the second and fourth are saleable. In some rotations, the Northumberland for instance, more food for the stock is provided, and often a catch-crop can be taken.

6. Some crops are good preparations for others. Thus leguminous plants, especially clover, are excellent for preceding a crop of wheat. They store up nitrogen in their roots, and thus provide for the great want of the cereal crop.

7. The increase of destructive insects and fungi is hindered, especially that of the former. When insects or fungi feed on any particular crop, they are destroyed or starved to death to a great extent before that crop comes round again. The conditions under which certain plants grow may be favourable to them, and the pests will increase if the same thing goes on year after year; but when these conditions are changed by different methods of growth and cultivation, they are more or less destroyed.

8. In a rotation the crops are more vigorous. When only one kind is grown, not only does the soil become exhausted, but the quality of the plants is lowered. Their seed has not such high germinative power, and they are more liable to disease. When a crop of clover is taken for several years in succession, it becomes affected with what is known as clover sickness. This cannot be properly stopped except by discontinuing the growth of this crop.

The Construction of Rotations.

Before giving actual examples, we will consider some of the principles affecting their construction.

Every rotation consists primarily of an alternation of corn and fodder crops, the fallow (bare or cropped) taking the place of the latter once in every course. Sometimes two fodder crops are taken together, when a large number of stock is kept. Again, on light lands, two root crops may be taken, followed by two of grain. As a rule, the land may be said to be alternately exhausted and replenished, and the crops must be arranged according to this plan.

A perfect rotation should include those crops which the situation, soil, and climate of the farm will admit of being cultivated profitably. We know that there are many variations as regards these points, and the following conditions modifying rotations may be considered.

Conditions Modifying Rotations.

1. **The Soil.**—Certain crops cannot grow with advantage on particular soils, and in all rotations this point must be carefully attended to. The crops suitable to the chief classes of land are as follows:—

Stiff Clays.—Wheat, beans, mangels, cabbages, kale, kohl-rabi, and clover. Bare fallows are often needed.

Loams.—Nearly any crop. They are the best soils for potatoes.

Light Land.—Barley, rye, peas, vetches, clover, white and yellow turnips and swedes, with catch crops.

Calcareous Soils.—All leguminous crops (peas, beans, clover, vetches, sainfoin, lucerne) flourish on such soil. They grow wheat well, and produce excellent barley. Good yields of nearly anything are obtained, if there is a sufficient depth of soil; and, as they are easily cultivated, they are very useful soils.

Peaty Soils.—Oats, rape, kohl-rabi, and potatoes. Rape is one of the chief stock fallow crops on peaty soils. Mangels and turnips are apt to become hollow in the middle. The potatoes are large and clear-skinned. Nearly all strawy crops grow fairly well.

Sandy Soils.—Rye, barley, lupines, and carrots. Wheat is unsuitable.

Deep Soils will grow most crops. They are essentially needed by carrots.

Shallow Soils are not so good. They are able to grow fair barley and turnips.

In making up a rotation for a certain soil, use the crops from the above list which are most suitable. Thus we have a skeleton rotation of Fallow, corn, fodder, corn. On light lands we would take Turnips, barley, clover or peas, wheat; on heavy clays, Bare fallow or mangels, wheat, beans, wheat would be given in preference.

2. **The Climate.**—Between the climates of the east and west of England there is a remarkable difference. The former is dry, the latter humid, consequently one is fitted for grain-growing, the other for stock-raising. In the south-east the best samples of cereals are grown, and the rotations therefore contain plenty of corn crops. In the north and west the seeds are usually allowed to lie down two or three years, less corn is grown, and as much food as possible raised for the stock. Again, in the south the best barley and wheat are grown. In the north first-class malting barley cannot be obtained; the hardier and coarser red wheat takes the place of the delicate white. Fine crops of oats can, however, be grown, and, consequently, this is the chief cereal

of the north. Swedes grow remarkably well in the north, while mangels do better in southern counties. In the latter districts catch-cropping is extensively pursued. A catch crop is one taken between two regular successive crops. Thus, on light land, after a corn crop, we may have winter rye, vetches, or trifolium, sown down on the broken stubble and fed off next spring. The land is then cleaned, and swedes taken. Thus, in two years, three crops are obtained. The later harvests of the northern districts to a great extent exclude this plan of operations.

3. **The Kinds of Live Stock** kept and the systems of their management may affect the rotation. Cattle need a large acreage of straw and fodder crops; sheep, a considerable proportion of roots to be eaten off on the land. Dairy cattle require succulent forage crops; fattening animals should have more dry food, such as straw. Horses do not consume many roots; therefore, when their breeding and rearing is an important feature in the farm management, the root acreage may be reduced.

4. **The Demand for Crops** and their market value may affect it. If a certain crop has a good demand and sells at a fair price, it is better to give it an important place in the rotation rather than grow another which is not so readily saleable.

5. **The State of the Land** with regard to drainage, cleanliness, etc., will make a difference. When land is full of weeds, such a crop should be taken as will allow of the land being thoroughly cleaned. Roots are well adapted for this purpose.

On undrained soils the number of crops that can be grown is lessened. The rotation may thus become restricted.

6. **The Lease of the Tenant.**—Some tenants are only allowed by their landlord to take certain crops, and these often have to be in some particular order. Thus two grain crops may not be allowed to follow each other; the land may have to remain at least two years in seeds, and other restrictions may be enforced.

The conditions just mentioned must all be taken into account before the rotation is decided upon. After suitable crops have been chosen, there is the proportion in which they are to be grown. This is regulated by (1) the cost of their cultivation, (2) their market value, (3) their value for home consumption and the number of live stock to be provided for.

Then we must fix the order in which they are to come, and, with regard to this, the following points require attention: (1) the special food requirements of the crop, (2) the ability of the crop to make use of the natural plant-food of the soil, (3) the mechanical effects on the land, (4) its action in the storage of plant-food constituents, (5) the opportunity given for cleaning the land. From these conditions, we see that there must be some fallow (bare or

cropped) in the rotation; two similar crops should not, as a rule, succeed one another; and from point 4 we see why wheat is taken after clover with such good results.

Fallows.

Fallows may be divided into four kinds: (1) bare, (2) root allow, (3) half or ragged fallow, (4) catch-crop fallows.

1. **Bare Fallows** are the oldest forms, and their acreage has now been greatly reduced. The early farmers became aware that the land was renovated by their use. But when the turnip crop was introduced on suitable soils, it was found to give an opportunity for thoroughly cleaning the land, and also had the advantage of producing valuable food for stock.

Bare fallows are taken on three classes of land: (1) on very stiff soils, (2) on very foul land, (3) on sour peats. Stiff clays grow good crops of turnip with difficulty, and then very often the farmer does not know how to dispose of them. They cannot be eaten off by sheep, and to cart them away is often almost as injurious. The excessive pressure causes a poor wheat crop, and, consequently, roots cannot be advantageously grown on such classes of land. In the second case, a root crop may not give sufficient chance of cleaning; or the land may be so foul, to begin with, that it cannot be got ready for the turnips. In the last instance, the oxidation brought about by bare fallowing neutralizes some of the organic acids.

By bare fallows great opportunity is given for the oxidation, and, consequently, part of the mineral ingredients of the soil are rendered soluble.

One great objection against bare fallows is their expense. During that year it is all outlay, no return being obtained. The fall in the price of wheat makes them much less profitable now than formerly, and it can be seen that they do not pay, unless we consider that their expense should be spread over the whole rotation. The good effects are certainly not exhausted by the next crop of wheat.

2. **Root Fallows** are the most important; they allow the land to be thoroughly cleaned from the time of the removal of the corn crop, say in September or early in October, up to at least March or April, when the first root crops (mangels) are sown. Then the seeds are nearly always drilled in rows, at such distances apart as to allow the free use of horse- and hand-hoeing implements between the lines. There are four reasons why roots are the great fallow crop. (*a*) They are not a success unless the land has been thoroughly tilled and is in good condition. (*b*) The late period

of sowing (for turnips, especially) gives a good opportunity of fallowing. (*c*) They are grown at wide intervals, so as to allow of hoeing and weeding during the period of growth. (*d*) The land must be well manured.

It is because of the use to which root crops are put that they are considered renovating. If they were sold off the farm, they would probably be found very exhausting. Being fed to the stock, however, most of their constituents are returned to the soil. On light lands they are often fed off on the ground by sheep. There would then be a loss of only those materials used by the animals for their increase. Against this would be the excellent consolidating effects from the treading of the sheep.

3. **Half or Ragged Fallows.**—In this plan some fodder crop, such as vetches, is sown in autumn, and cut for fodder late in spring. The land is then broken up in June or July, and fallowed. Wheat is taken in autumn. In the same way clover, seeds, trifolium, or trefoil may be used. The course of operations is suitable for heavy soils, the fodder crop being mown or fed at a time when little damage is done to the land from treading.

4. **Double-cropped Fallows.**—Suitable for light land. Vetches, trifolium, trefoil, rye, winter barley, or oats, etc., are sown in autumn, and mown or fed off in spring. The land is then broken up, and turnips or swedes taken. In this way a greater amount of food for stock is obtained. This system is known as catch-cropping. It can only be done when harvest is fairly early, and the soil must also be clean.

When writing down any rotation, the fallow should occupy first place. It is a definite starting-point, and its recurrence really bounds the rotation. The introduction of a fallow into the middle of a rotation breaks it. Thus the following may be taken for such a faulty example :—

(Roots, oats, clover, wheat), (*turnips*, barley, peas).

It really consists of a four and a three years' course.

Another great mistake would be to take a rotation without a fallow; such as—

Oats, clover, wheat, beans, wheat.

Such an example has no commencement and no end.

Examples of Rotations.

Rotations are called two-, three-, four-course, etc., according to the number of years occupied in getting through them.

Two-course.—Wheat; beans or clover. It is suited to some

heavy, fertile clays, but is rarely used. It is taken on some farms in America. It has no fallow, and does not provide to any extent for stock.

Three-course.—Fallow (bare); wheat; beans, oats, or clover. Employed on some of the heavier and poorer classes of soils. It is practically the same as the old three-field course of the Saxons. The advantages are, that it requires little capital and there is a rapid return of the farmer's money. The disadvantages are, that there is little variety of crops; few stock can be kept; and the rapid recurrence of the fallow is expensive.

Four-course.—For this the Norfolk rotation, a most typical example, may be taken. It is—

Roots; barley; clover; wheat.

The roots consist of turnips and swedes, with mangels, cabbages, rape, kohl-rabi, and potatoes in less abundance. Italian rye-grass, or some leguminous crop (peas, especially), may occupy the place of the clover.

It is very well suited to light lands and the feeding of sheep. The sheep are folded upon the turnips, and the land thus becomes well consolidated. The soil is left in an excellent mechanical condition for the succeeding barley, upon which the clover is sown. This crop stores up nitrogen in its roots, and a good yield of wheat is the result.

The Norfolk rotation is subject to many modifications, some of which we will consider later on.

Five-course.—Roots; wheat, barley, or oats; seeds; seeds; oats. This is known as the Northumberland or Cumberland rotation, and is very suitable for a cold, humid climate, like that of the north of England. The roots consist chiefly of turnips and swedes, as these flourish better than mangels. The seeds are left down two years, and this is an important alteration in the economy of the farm. The fallow is not so frequent, and there is only two-fifths corn instead of one-half, as in the Norfolk rotation. The difference may be simply expressed thus: More stock and less corn. Wheat has been found not to flourish so well after clover in the north as in the south. Probably the colder climate prevents the proper decay of the clover roots. The humid climate, however, favours the full development of oats, and hence this crop is often taken. Another important feature of the rotation is that the lea need not be broken up until January for oats. With wheat to follow, it would be ploughed up in August and September. Thus, in the former case, the autumn and winter feed is increased, and the ewes do well on the old clover then. The oat straw is valuable fodder, and oats still keep up their price in contrast to wheat.

Again, the labour bill is reduced, two-fifths of the land each year requiring little attention.

Six-course.—Fallow (bare or cropped), wheat, clover (mown or fed), wheat, beans, wheat. Known as the Holderness rotation, and practised on rich, stiff land.

Potatoes or beans (manured), wheat, green crops (manured), wheat or barley (half manured), seeds, oats (top-dressed). Known as the East Lothian six-course, and suited for heavy, rich land.

Another East Lothian rotation is—Roots, barley (half dunged), clover, seeds or oats (top-dressed), potatoes, wheat.

Seven-course.—I. A rotation, from the Carse of Gowrie, suitable for very rich clays: Fallow, wheat, barley, clover, oats, beans, wheat. II. Mangels and vetches, wheat, clover (twice cut), clover (once cut, then fed), wheat, beans, wheat.

Modifications of Rotations.

All the rotations just given can be greatly modified. Thus we will take the Norfolk rotation.

Original.	Skeleton.	Modifications.		
Roots. Barley. Clover. Wheat.	Fallow. Corn. Fodder. Corn.	Mangels. Wheat. Vetches. Wheat.	Swedes. Oats. Peas. Barley.	Cabbages or rape. Wheat. Italian rye-grass or clover. Wheat or oats.

Again, by leaving the clover and seeds down two or more years, a five-, six-, or seven-course rotation will be obtained.

The old three-field rotation, being found to give too little variety of crops, has been altered thus:—

(1) Fallow.	(1) Half bare fallow. Half mangels or other roots.
(2) Wheat.	(2) Wheat or oats.
(3) Beans.	(3) Half beans. Half clover.

In the new form, at least two fresh crops are introduced, and the bare fallow is reduced one-half.

The Northumberland rotation is really a modification of the four-course, with seeds taken instead of clover, and left down two years. We also find other forms; as—

(1) Roots (and green crops). Wheat. Barley. Seeds. Wheat.	(2) Potatoes. Wheat. Barley. Seeds. Seeds.

Number 1 is for a loam; number 2 is suitable where most of the crops are to be sold off the farm, the seeds being made into hay. In the latter case the form may be altered by giving barley the fifth place, the seeds succeeding the wheat.

The number of six-course rotations are very great. They can be divided into three groups, according as their seeds lie down one, two, or three years. The latter forms are simply extensions of the Northumberland; everything being the same except that there are three years' seeds instead of two. The labour bill is reduced, and more stock can be kept.

The following are on the first plan:—

(1)	(2)	(3)
Roots.	Turnips.	Roots.
Wheat.	Barley.	Wheat.
Beans.	Clover.	Beans.
Wheat.	Oats.	Barley.
Seeds.	Potatoes.	Seeds.
Oats.	Wheat.	Wheat.

The following are examples of the second method:—

(1)	(2)	(3)
Roots.	Turnips.	Roots.
Barley.	Barley or oats.	Oats.
Clover and seeds.	Seeds.	Seeds.
Lea.	Lea.	Seeds.
Oats.	Potatoes.	Wheat.
Wheat.	Wheat.	Barley.

Rotations for Light and Heavy Lands.

In making up rotations for these soils the crops mentioned previously should be used according to how they are classed. The most typical *light land* course is the Norfolk. It has been given before with some of its modifications.

Among other suitable rotations are—

I. (1) Vetches, fed and followed by late-sown turnips fed off.

(2) Early sown turnips.

(3) Wheat (sown in autumn chiefly).

(4) Barley.

(5) Winter rye, barley, or trifolium, fed off in spring. The land is then broken; swedes are taken and fed off by sheep.

(6) Barley.

(7) Clover.

(8) Wheat.

This really consists of two rotations. The advantage of having two root crops in succession is that they provide plenty of food for the wheat. In this way, on poor soils, a good wheat crop can be grown, followed by a fine crop of barley of

excellent malting qualities. Should the barley precede the wheat, the former will be coarse, and the latter give a poor yield.

Others are:—II. Turnips, barley or oats, peas, wheat. III. Turnips, barley, seeds, seeds, oats. IV. Roots, barley, peas, wheat and oats, clover, clover, wheat.

On *heavy land* bare fallows are used. Some of the chief rotations applicable here are—

I. The Holderness, and, II., the old three-course, given before.

III. (1) Mangel-wurzel, cabbages, kale, or rape, or even early sown white turnips, (2) wheat, (3) beans, (4) wheat, (5) oats.

IV. (1) Winter vetches, fed off, and the land then broken up, and sown with white turnips, rape, or even vetches again.

(2) Wheat sown down with (*a*) trefoil, (*b*) mixed seeds, and (*c*) a small portion of the stubble with trifolium.

(3) (*a*) The trefoil is mown, and then broken up for turnips; (*b*) seeds mown or fed; (*c*) trifolium mown, and then broken up for turnips, rape, etc.

(4) Wheat.

(5) Winter beans. After the bean stubble has been cleaned, vetches are sown.

This rotation was constructed to enable sheep-farming to be carried out on stiff clays.

Bad Rotations.

In every rotation there should be a fallow; without one it may be considered bad, as the land will get foul. An example would be: Beans, clover, wheat, barley, oats. Again, it is not generally advisable to take two grain crops in succession. When a farmer has got his land into a high state of fertility, he may, however, do this without injury. Some agriculturalists believe in continuous wheat-growing. Sir J. B. Lawes has conducted experiments upon the subject at Rothamsted. With everything removed from the land, the average yield for the fifteen years, from 1874 to 1888 inclusive, was $11\frac{5}{8}$ bushels. With fourteen tons of farmyard manure, however, the mean for the same period was $32\frac{7}{16}$ bushels; and this would not point to the conclusion that the land was being exhausted. If the price of wheat were to rise again, the continuous growth of this crop might come into favour. The method would go against stock-farming. While wheat appears to flourish, clover becomes weak and subject to "sickness" by being taken year after year. Turnips also soon fail when no farmyard manure is given. Thus, at Rothamsted, a plot giving 4 tons, $3\frac{3}{4}$ cwts. one year, only gave $13\frac{3}{4}$ cwts. the second year. With farmyard manure, twelve tons per acre,

the crop was almost doubled in the same time. With plenty of tillage and manure, the average crops of wheat may be kept up; but it will not pay the ordinary farmer, especially at present prices, to go in for such a course of farming.

B.—*Preparatory Culture.*

We have already studied the subject of rotations, and now proceed to look more thoroughly into the individual characteristics of the growth of each crop.

Professor Wrightson has proposed the following syllabus for the study of crops. The points are grouped under three heads, viz. those based (*a*) on certain preliminary considerations, (*b*) on chronological events, (*c*) on accidental circumstances connected with the plant.

The points are:—

(*a*) 1. Position of the crop in the vegetable world.
2. History and origin.
3. Cultivated varieties.
4. Place in rotation.
5. Soils suitable.

(*b*) 6. Preparation of the ground.
7. Time of sowing.
8. Method of sowing.
9. Amount of seed used.
10. Fertilizers employed.
11. After cultivation.
12. Harvesting.
13. Preparation for market or for home consumption.
14. Cost and return.

(*c*) 15. Insect attacks.
16. Fungoid diseases.
17. Nutrient properties or composition.
18. Cost of production and realization, etc.

Under these headings all our knowledge of farm crops can be conveniently arranged. The Insect Pests and Fungoid Diseases are treated in separate chapters.

The subject of crop cultivation we will divide up under three heads: (1) The Preparatory Culture (2), The Sowing and After Culture, (3) The Harvesting.

1. The Preparatory Culture of Farm Crops.

As cereals are of the greatest importance, they are taken first.

Wheat does not always occupy a fixed place in the rotation,

but when a bare fallow is taken, wheat usually succeeds it. The soils most suitable are the heavy clays. On well-cultivated light lands good crops can be grown, but they need to be liberally treated and often to have two successive root crops. The climate should be fairly dry, and the elevation must not be above 1000 feet. Range of temperature, from 44° to 78° F. As wheat is taken after such a variety of crops, the preparation of the land varies greatly. Again, as some wheat is sown in autumn and some in spring, this affects the consideration.

(1) After bare fallow or roots. This is the simplest case and least expensive. The land is simply shallow ploughed, say to a depth of four inches. A little farmyard manure is sometimes spread over the surface before the ploughing. The seed is then sown, and harrowed in.

(2) After clover and seeds. Plough the vegetation under in August or September, using a skim coulter, and not going deeper than four or five inches. By this means a fine top and firm bottom are obtained. Then harrow well after about six weeks, and drill in the seed. It is then harrowed in. Another method is to plough, then go over the land with the presser or roller, sow the seed on the pressed furrow, and harrow it in.

(3) After peas or beans. The land is sometimes dunged, and then ploughed once. It is harrowed to get rid of the weeds, the clods being reduced as little as possible. The seed is then sown.

In all these operations it should be remembered that the surface soil should not be made too fine, or it is apt to cement together through winter, forming a hard "cap." The clods also protect the young wheat from cold winds, they naturally crumble under the action of frost, and are easily reduced by the roller in spring. The land must also be firm, and this is the reason why it is nearly always rolled or pressed.

Barley is essentially suited for light soils. In the Tertiary formations, the drift soils are most suitable. Many of the Cretaceous are excellent; the Lower Green Sand and Gault are not adapted for barley-growing. Most parts of the Oolite are good; the Oxford Clay and the Lias are, however, the reverse to this. On the soils from the formation below this, barley can usually be grown satisfactorily, provided, of course, they are of good composition and the climate not too cold or wet. This last point should be well remembered. To get good malting samples, the climate must be warm and dry, and hence the reason why this cereal is most commonly grown in the south-east of England. The mean summer temperature must not fall below 49°. Barley occupies the second place in the Norfolk rotation, succeeding

roots. By this plan, however, though a large crop may be obtained, it is often coarse, and this led to the method of taking barley after wheat, two root crops being grown previously to put the land into sufficiently good condition. The sample thus obtained is much more valuable for malting purposes.

Winter, or six-rowed, barley is often used as green fodder, and preparation of the land for it is all done in autumn.

As soon as the roots are got off, the land should be shallow-ploughed, and left through winter. In spring, all the weeds are got rid of by repeated harrowings and scufflings. As soon as a fine and thorough tilth is obtained the seed may be drilled and harrowed in. Barley should never be sown on a stale furrow.

Oats are the chief cereal of the North of England and Scotland. They suit nearly all soils, and develop best in a cool, moist climate. They are very hardy and grow in higher latitudes than any other cereal crop, except rye. Friable soils are the best for oats. They do well on peaty soils, and are about the first grain crop taken after breaking up moorlands. They occupy the fifth, and often the second, place in the Northumberland rotation. Winter oats are used as fodder.

The preparatory cultivation is similar to that for wheat. The leas, which it usually follows, are ploughed down in autumn and harrowed well in spring. The seed may be drilled or broadcasted, and then a harrowing given. After ploughing up the clover, the presser is sometimes used. The seed, when broadcasted, will then often be deposited in the lines left, and will be more easily covered over by the harrow. Oats do best on a well-prepared seed-bed, though it is not absolutely necessary to have a very fine tilth.

Rye is a cereal very little grown in England. It has no fixed place in any rotation, and is cultivated more for the green fodder than for the grain. It is extremely hardy, and suits light poor soils. It can be grown on a nearly pure sand, and also on mossy land where oats would lodge. It is usually sown after wheat and is of value for preceding turnips, when used as a catch crop. The preparation of the land simply consists of about two ploughings and as many harrowings as necessary to get it clean. Grubbing would do well. When the fields are clean, one ploughing, at a depth of four inches, and a few harrowings, are all that are needed. After sowing the seed in autumn, a harrowing should be given, but it is not advisable to roll.

As rye grows well under trees, small amounts are sometimes sown in woods for pheasants.

Beans alternate with wheat on the heaviest classes of land. In Scotland, they are largely grown on the Carse lands, which consist

of alluvium. Like other Leguminosæ, they do well on calcareous soils, and especially on the marls. Bulky crops are obtained on the fenlands, but the yield of seed is not great, and the straw is usually overgrown.

A dressing of farmyard manure, about sixteen tons per acre, is often given to beans. The dung is spread over the field, and then ploughed in soon after harvesting the previous crop. The land is then harrowed, and the seed sown either in autumn or spring. In the latter case some of the harrowings would be given through winter. In the north, the bean land is usually made up into ridges, twenty-four inches apart, just as for turnips. The dung is spread between the ridges, which are then split over it by means of the double-mouldboard plough. The seed is then put in as before.

Peas are suited for the lighter calcareous soils. They grow well on gravelly and sandy soils when these have been recently limed. They are not often grown as a regular crop in a rotation, and are not an ordinary farm crop. They may be taken with beans, in the proportion of two of beans to one of peas. Most of the crop is grown in the south-east of England.

The fields for peas should be ploughed as soon as possible after harvest, as the crop does best on a stale furrow, in opposition to beans. The land should be clean and in a fine state of tilth, this being obtained by numerous harrowings. The scufflers would be at work first; they are followed by the drag-harrows and then by the light harrows. The ground should never be worked when wet; the seed should also be drilled during fine weather, and harrowed in.

It is not advisable to dress the land intended for peas with dung, as the crop is rendered coarse and the flavour of the peas deteriorated.

We now come to the **Root Crops**, which have been mentioned before as being used for cleaning or fallowing.

The preparatory cultivation of all our root crops is almost the same, and consequently can be well considered together. It is essential that the land be thoroughly clean, and in a fine state of tilth. For this purpose autumn cultivation is most suitable.

As soon as possible after harvesting the preceding corn crop, the land should be shallow-ploughed to a depth not greater than three or four inches. The object is to pare off the surface weeds, and consequently the old practice of raftering might here be performed with advantage. The weeds are buried, so as to be rapidly decomposed. After this ploughing, the land, when light, has the cultivators passed through. Their long, curved teeth drag

out such creeping weeds as couch grass. Then use the scuffler, which increases the fineness of the clods; and collect the weeds by means of the chain-harrow. Burn the rubbish. This plan of operations may have to be repeated, taking care that the surface soil be not rendered too fine. It is very necessary that all these operations be performed in dry weather. If worked when wet, the soil dries into hard clods, which, when broken down by harrows or rollers, do not crumble, but only form small angular fragments. These particles are totally unsuited for being the home of young plants. As the period after harvest during which land can be worked without injury is somewhat short, steam cultivation has often been recommended. The land is quickly operated upon, and is thoroughly smashed up. The cultivator is the most suitable implement for this purpose. It should be worked twice across the fields, the second turn being at right angles to the first. Between the two operations a rolling may be given.

Owing to other work, such as the preparation of land for wheat or beans, it is almost impossible to get all the root land thoroughly cleaned before winter. The part intended for mangels should therefore be cleaned before the rest, as this crop is sown much earlier than the others. The land is prepared in a manner similar to the above. A dressing of dung is given, and then ploughed in.

The work is commenced again as soon as possible in the next year. In January or February, if fine, the land may be cross-ploughed, the direction being at right angles to the former furrows. Some farmers recommend a harrowing just before this to produce a level surface. The object is now to produce a fine, moist seed-bed, and in order to push forward the work the steam-cultivator may again be used with advantage. The ordinary grubbers and drag-harrows have often to be used instead; and in the former case, also, they will soon succeed the steam implements. After the grubber will come the lighter harrows, and then the weeds brought to the surface will be collected by the chain harrow. These operations, if properly carried out, ought to leave the surface soil fine enough. In the north, the stubble is simply ploughed in autumn, cross-ploughed and well cultivated in spring; when fine enough, the land is formed up into ridges with the double-mould-board plough, and a dressing of about twelve to sixteen tons of farmyard manure spread between the ridges. The dung is usually deposited in small heaps from a cart, enough being left each time for about five rows. The cart goes up the middle of this plot, and the manure is then spread in the bottoms of the ridges, by women with forks. The artificial manure is sown, the ridges split over the manure, and the seed drilled in on the top. One great advantage of this system is that the surface soil is

grouped more about the roots of the young plants, which are also immediately over a rich store of plant-food constituents.

In the method employed chiefly in the south of England, no ridges are raised. After the last harrowing, the land is rolled to get it as flat as possible. The dung is applied before the commencement of the spring cleaning operations, being simply ploughed in.

Roots have a more critical cultivation than any other common crop. Everything depends so much upon the weather, that the farmer has to possess considerable foresight. The bad effects of working the land when wet have been mentioned. The land should never be rolled or harrowed when moist, as hard masses generally form. When the soil is light, in a dry climate a good rolling consolidates it, and helps it to retain moisture. The effect of harrowing at such a time would be to favour the evaporation of water, and the result would be that the crop would not be able to grow. The conservation of moisture is of such importance that some farmers scarcely touch their land in spring. They clean it thoroughly in autumn, and then give it a deep winter furrow. A short time before sowing the seed, the land is harrowed a few times, formed up into ridges, and the seed sown.

Though cross-ploughing in January or February may do good on dry soils, yet it is not generally advisable to use the ordinary plough afterwards. The fine surface soil is buried, and the beneficial effects of much of the previous treatment are rendered useless. The rough material brought up is often not sufficiently pulverized before seed-time, and, if dry weather continue, the loss of moisture from the surface would produce injurious results.

On heavy lands it will be seen that autumn cultivation is absolutely necessary for the root crop. A dressing of dung should be applied then, and a good deep winter furrow given. The latter partly provides for the surface drainage of the land. On light soils there is not such great need of autumn cultivation. They are easily worked in spring. On the two classes of land there is an important difference in the manner of destroying the weeds. On the former they are killed in the clods, therefore these should not be reduced too much in size, and, as the death of weeds is caused by lack of moisture, they should be frequently turned in dry weather. On the light soils the surplus vegetation is destroyed by exposure on the surface.

On clean land few cleaning measures need be undertaken. Almost all that need be done in this line is to send a set of labourers with forks over the fields in autumn. Any stray patches of couch or other weeds are dug out with the forks, and then collected and destroyed.

Turnips and Swedes, being the principal fallow crops, occupy the first place in nearly every rotation. They are best suited for light and loamy lands. On the weakest sands, white turnips are taken; on the light loams, yellows as well are grown. Swedes, with the other two, are cultivated on the clay loams; this crop does not thrive on very light sands. As to climate, the cool and humid north of England and Scotland grow both larger and better crops than the south. A difference in the preparation of the land is also seen in the two parts; in the former it is put into ridges; in the latter it is left flat. However advantageous the ridges may be in their own districts, they do not succeed in the south. The objection against them is that they assist the evaporation of moisture, leaving the land too dry for the plants, and favouring the attack of that fungoid disease known as mildew.

Mangel-wurzel are another important fallow crop. They do best on good deep loams, and suit heavy soils very well. They are a failure on the thin chalks. They succeed most in warm climates, and stand drought well. For this reason they are largely grown in the southern counties. The cultivation is very similar to that already given; the land must be cleaned in autumn, and some long dung ploughed in during December. Early in spring a dressing of seaweed may be given, if near the sea. Work with the harrows until a fine tilth is obtained; then form up into ridges, if the district is at all suitable, and drill the seed. On heavy clay as little work as possible should be done in the spring, or a proper seed-bed will not be obtained.

Carrots are not a very regular crop. They grow best on good deep light soils, free from stones. On heavy lands, besides a poorer yield, the crop would be very difficult to dig up. Carrots essentially need deep cultivation; subsoiling is often of great use. The autumn preparation of the ground is the same as for mangels, the ploughing, however, being deeper. Little is done in spring, owing to the early seeding. The land may be harrowed and rolled in dry weather, before sowing.

Parsnips are only rarely grown as a farm crop. They need almost the same cultivation as carrots, but it is less critical.

Cabbages.—The most suitable soils are deep rich loams, but they grow well on very stiff clays. They are well adapted for the latter classes of land for several reasons. (1) Stiff soils give good crops. (2) Being sown in small plots, and then transplanted in September or in April, they allow of the autumn cultivation of the land. (3) They can be fed off on the land in July and August, when little damage will be done by trampling.

The land is thoroughly cleaned after harvest, the stirring

being to a good depth. Very fine surface soil should not be aimed at, as it is best for the frost to crumble down the clods. A heavy dressing of dung should be given. It is laid at the bottom of the ridges as for mangels, and covered in the same way. Ridges are not, however, always formed, the crop being often grown on the flat. In this case the farmyard manure is applied in autumn, before the winter furrow is given.

Kohl-rabi grows well on loamy soils, whether heavy or light, and also on the fen-land. It is hardy, but is not often seen in the north, being chiefly cultivated in the southern and midland counties. The land is worked the same as for mangels, being deeply ploughed in autumn and then grubbed in spring.

Rape suits alluvial or peaty soils best, and, after these, heavy clays. It is grown, however, upon a great variety of soils, and does well upon the chalk. Its cultivation is very similar to that of swedes; plenty of manure is required.

Thousand-headed Kale.—The preparatory cultivation of this crop is the same as for cabbages. It suits a wide range of soils, and has been found to do well on poor chalky land.

Potatoes grow best on deep, warm loams. The best potatoes are said to be grown on the Old Red Sandstone. The heavy clays and weak sandy soils are more unsuited to their growth, though with plenty of manure the last named may give good crops. Peaty soils produce very good tubers, but on the fenlands the quality of the very heavy crops obtained cannot always be relied upon. They are apt to be hollow and watery. As regards the season, they do best with plenty of rain at first and then dry weather after. Their place in rotation is not always with the fallow crop. They answer well for preceding wheat and succeeding oats.

The land for potatoes must contain plenty of available plant-food; it must be clean, well drained, and free from acidity. The last two points need attention on peaty soils.

Potatoes are grown on three systems: (1) on the ridge, (2) on the flat, (3) on the lazy-bed method. The first plan is decidedly the best. The stubbles are ploughed up in autumn, and cultivated as for roots until the sets are planted. On the second method, the land is ploughed in autumn, and gets twenty or thirty tons of farmyard manure per acre. Another ploughing is given in spring, before planting. The lazy-bed method is suitable for wet boggy lands, or those that are rocky. It is described later on.

We must now consider the chief fodder crops.

Vetches suit nearly any class of land, provided it contains a sufficient amount of lime. Like many fodder plants, they are chiefly grown as a catch crop, for which purpose a moist, but

warm, climate assists greatly. The cultivation is very simple. They are generally taken after a corn crop (wheat especially), and the stubble needs ploughing up. Dress with ten or twelve tons of dung per acre, and then plough to a depth of four inches. Harrow until the furrow slices are broken up, drill the seed and harrow it in. All these operations are got through as quickly as possible, so that at least part of the crop may be got in during autumn.

Trifolium, or crimson clover, produces good crops, especially on loamy soils. It may do well on land of heavier description, but does not thrive on weak sandy soils or on chalky land. It requires the warm climate of the southern counties. The cleanest piece of stubble is lightly cultivated or drag-harrowed two or three times, then the seed is sown, harrowed in, and rolled. On heavy land a shallow ploughing may be given to begin with; but it is better not to use the plough at all. It loosens the soil too much, and a firm seed-bed is needed by the plant.

Trefoil thrives best on the calcareous soils of the south. No previous preparation of the land is made specially for this crop, as it is sown upon the young corn.

Italian Ryegrass may be sown upon wheat or by itself. In the latter case, which is not so common, the soil needs to be cleaned and harrowed as soon after harvest as possible.

Sainfoin is most suitable for calcareous soils. It is sown down with barley, on very clean land.

Lucerne.—A deep calcareous loam is best, with dry climate. The ground should be cleaned thoroughly in autumn, and ploughed just before winter. In spring, a dressing of rotten dung should be given, and a good seed-bed prepared.

Lupines suit sandy soils, but are seldom grown in this country. The land needs to be cleaned in autumn and spring, as for the other crops.

Gorse may be grown on poor sandy soils. The land is broken up as much as possible, so as to get a fine seed-bed, and the seed sown in March or April.

Prickly Comfrey may be taken in out-of-the-way corners, especially when low-lying and wet. It requires a somewhat deep, rich soil. The land needs to be cleaned and well manured with dung before planting.

Mustard.—The brown mustard, grown for seed, is cultivated chiefly on the rich alluvial soils of South Lincolnshire. The white variety, used for forage and green manure, is not good enough for the very fertile soils. It may be grown upon the higher loams.

The tillage operations should be deep, and the soil must be

well divided up. A good dressing of well-rotten dung may be given. The seed is sown in April. With the forage crop, the seed may be sown upon a shallow furrow, and ploughed in.

Maize is scarcely suited for an English climate. The land needs to be well-prepared and dunged.

Hops suit rich calcareous loams with a warm climate. The greater part of the crop grown in Great Britain comes from Kent. The ground needs to be sheltered and well drained.

The land is trench-ploughed or deeply ploughed and subsoiled in autumn. The former operation is best, when properly performed. A heavy dressing of dung is given about the same time. It is a good plan to fold sheep upon the land in autumn, and give them a liberal allowance of cake or corn.

Flax requires rich fertile land in good tilth and clean condition. It does not suit either heavy clays or gravels. It usually follows a corn crop, but also does well after potatoes.

The land should be ploughed at the beginning of winter, and then cross-ploughed in spring, during fine weather. Work out the land with the harrows, getting a firm, even seed-bed.

Hemp is grown in small amounts on rich alluvial soils in Lincoln and Dorset. The preparatory culture is the same as for flax.

Buckwheat suits poor, light, dry soils, and, as it does fairly well under trees, is sometimes sown in small quantities in woods and odd corners, for pheasants or poultry. It may follow a corn crop if the land be clean enough.

Teazles are grown chiefly on poor clays in the south. The land is ploughed and cleaned in autumn, and the plants dibbled in.

Jerusalem Artichoke suits the poorest sands and any odd corners. The soil is simply ploughed up, cleaned a little, and manured.

2. Seeding and After Cultivation.

Previous to reading through this section, the different machines by means of which crops are sown should be studied (see pp. 36–38).

Wheat may be sown either in autumn or in February, and from this fact we get autumn and spring wheat. The usual time for putting in the former variety is in October or November. After a bare fallow it may be sown a little earlier.

Wheat should be sown on a moist seed-bed, and on light lands it can scarcely be too wet. Care must be taken that the ground be not harrowed much when in a wet condition. The tilth does not need to be so fine for autumn as for spring corn ; the clods protect the young plants from the winter blasts, and gradually crumble down under the influence of atmospheric agencies.

The amount of seed per acre varies from one and a half to three bushels. Less wheat is sown per acre in autumn than in spring, and the reason for this is readily apparent. The former has much longer time to grow, and tillers more. The term tillering applies to the number of stems a plant produces. In elevated, cold, or wet districts, thick seeding is practised. The crop does not tiller much, and unless the straw is close together it has a greater liability to be blown down. In the Midlands and South of England, with a warmer climate, the least amounts of seeds are used, and one bushel and a half is a very usual quantity when drilled.

Spring wheat should always be grown from spring wheat, and autumn wheat from that which has been always sown at that time. Spring wheat is not so hardy as the other variety, and could not stand the winter so well. The hardihood of the autumn kind would not be of any great use if sown in spring, and, being naturally a slower grower, it would be later in maturing, and would probably yield a poorer crop.

Before sowing, the seed is often steeped in a solution of blue-stone, three ounces to the bushel, or in boiling water, to kill bunt and smut germs. At the same time it may be dressed with tar, one pint to four bushels, to keep birds off.

There are two chief methods of sowing, (1) by means of drills, (2) broadcast. The second method is performed usually by the hand, but there are also broadcasting machines. When done by the hand, about fifteen acres can be finished per day by one man. The seed is contained in a linen bag fastened round the man's body, and often over his shoulder, and may be distributed either by one hand, or both. The arm is brought round with a sweep, the fingers gradually opening, and an advance being made with the foot at the same time. If the actions be not simultaneous, an equal distribution will not be secured. The broadcast machine deposits the seed very regularly, and is much used instead of the old method. Drilling is now greatly employed, and has three advantages over broadcasting: (1) less seed is used, 2 to 3 bushels being required; (2) the seed is more evenly deposited, and is all at one depth; (3) the land can be hoed between the rows. The disadvantages are that drilling entails more labour and takes longer than broadcasting. In drilling, the rows are usually eight or ten inches apart. A good way of seeding is to run a presser over the land, broadcast the seed and harrow it in. It is really a modified form of drilling, as most of the seed falls into the hollows left by the presser. Two to three hands, with the same number of horses, drill ten acres in a day of eight hours.

After broadcasting the seed, the land is harrowed as soon as possible. This covers the grain, and prevents the ravages of birds. After this the furrows between the "lands," or "cuts," are cleaned out, so as to allow of surface drainage. This is most important with autumn wheat on heavy clay.

In spring the wheat may be rolled and harrowed. The rolling presses the soil firmly about the young roots. When the autumn wheat is very forward many farmers fold sheep on the land. The young sprouts are eaten down, and the soil consolidated. Harrowing is said to thin too thick wheat, and increase the number of plants when too thin (by promoting tillering). A turn of the harrow is also given to the autumn wheat in spring, to break down any clods when in a dry state.

Should the crop not be doing well, it may receive a dressing ot 1 cwt. nitrate of soda, and $1\frac{1}{2}$ cwts. superphosphate, or of 2 cwts. Peruvian guano, applied about April. Manure is not, however, often given to the crop.

Drilled wheat is hoed during its early growth. The operation must not be performed when the ground is at all wet. Either the horse- or hand-hoe may be used. With the former, from eight to twelve acres can be done per day; with the latter, half an acre. The land is kept clear of weeds, but the process is expensive. Horse-hoeing costs nearly one shilling per acre; hand-hoeing from three and sixpence to six shillings.

The Lois-Weedon System of Cultivation.—This plan has been devised to allow of continuous wheat-growing, and is based upon the precepts laid down by Jethro Tull. The land is thoroughly cultivated, and then wheat is sown. Three rows are drilled in a foot apart, then comes a three feet interval, followed by three more rows of grain. The wide intervals are thoroughly tilled during the growth of the crop, and serve as next year's seed-bed. By this method very good crops of wheat can be grown year after year. The tillage expenses are heavy, and the system seems to have nearly died out.

Barley is sown from about the middle of March to the end of April, and even as late as May. Late seeding is not, however, to be recommended.

The seed-bed should be deep and fine. Broadcasting by hand does not answer so well for barley as for other cereals; owing to the state of the soil at the time, the seeding will not be even. The broadcast machine and the drill do good work. Great care must be taken with the seeding, as it is very important that the crop be very regular, otherwise the sample will be uneven, and reduced in market value.

The amount of seed used varies from $2\frac{1}{2}$ to 4 bushels per

acre. Less is required when sown early than late. As little as two bushels may be used with the drill.

Warm, moist weather secures a rapid germination; but heavy rain, especially when accompanied by cold breezes, causes a poor crop.

Barley does not require much after-cultivation. It may be harrowed or rolled soon after seeding, and, when it has been drilled, may be hoed the same as wheat.

Being a quick-growing crop, barley requires a plentiful supply of readily available plant-food. A dressing of 2 cwts. superphosphate with 1 cwt. nitrate of soda or sulphate of ammonia may be given. The ammonium sulphate may be put in with the seed; when the nitrate is used the manure may be applied as a top-dressing a few weeks later.

Winter barley (*Hordeum hexastichum*) may be sown broadcast in autumn. It does not require such careful cultivation as the ordinary varieties, and is used for forage.

Oats are usually put into the ground during March, though the seed time may be prolonged into April. The earlier time is the best. The commoner kinds are sown first; the improved varieties may be kept a little longer. The early sorts are most suited for exposed districts.

The seed may be sown either broadcast or with the drill. The broadcast machine is very often used. The amount of seed per acre is from 2½ to 5 bushels; the larger quantity is more common. It has been recommended to sow mixtures of two or more varieties of oats together.

The land is harrowed well before and after seeding, all traces of the old furrows being got rid of. No further cultivation is usually needed.

The manuring is the same as for barley. Peruvian guano is a very good top-dressing. It must be remembered that, in practice, none of the three great cereal crops are manured, as a rule.

Rye is usually sown in autumn, September being the best month. The land is ploughed, harrowed, the seed sown and harrowed in. The amount of seed used is from two bushels when drilled, to three or four when broadcasted. No attention is needed through winter, and by March or April it will be fit for folding.

Beans are sown both in autumn and spring. The autumn beans should be planted as early as possible (in October, or early in November), so that they may get well established before the frosts commence. The spring beans are sown in February, if possible; the work may be continued into March, but none should be sown after this month. The greater part of the crop is usually of the spring variety.

Beans are sown either in ridges, in rows, or simply on the flat surface. In the more northern counties the first method is in favour. The ridges are from twenty-four to thirty inches apart, and allow of the free use of the horse-hoe. They are more commonly grown in rows on the flat. The distance between the rows varies from fifteen to twenty, or even thirty inches. When wide apart, the land can be hoed more easily, but a less number of plants can be grown. Fifteen to eighteen inches between the rows may be taken as the usual distance. It has been recommended to grow the beans in rows alternately twelve and twenty inches apart. Beans are usually drilled in, but they may be sown broadcast on a smooth surface. Sometimes they are dibbled in. Mechanical means may be used for this, or a labourer may make the holes with a dibble, and the beans are dropped into these, and covered in.

The amount of seed used varies from two to three bushels in autumn, and two to four bushels in spring. Before drilling on the flat, the land should be well harrowed, and afterwards two or three harrowings are given. After dibbling, the harrows should be worked once or twice. One advantage of dibbling on heavy land is, that the danger of treading by horses is removed.

The manure for beans consists of ten or twelve tons farmyard manure (the poorer kind will do), ploughed in during autumn. A dressing, of 1 cwt. sulphate of potash, and 1 cwt. superphosphate, may be given about March. When no dung is applied, the following mixture may be used instead: 2 cwts. sulphate of potash, 2 cwts. superphosphate, 1 cwt. bone meal, and 1 cwt. sulphate of ammonia. This should be put in about the same time as the seed is sown.

When the young plants appear above the surface on the ridge system, say ten days after sowing, the saddle-harrows are put to work loosening the soil. Dry weather is needed for this. As the crop gets a little higher, the land is horse-hoed once or twice. After this they are hand-hoed enough to keep them clear of weeds. When the rows are near together the after cultivation does not include horse-hoeing. After the plants begin to flower it is not safe to work amongst them; previous to this they should be hand-hoed three or four times.

The method of sowing in rows, and the subsequent hoeing, explains why such a rotation as wheat, beans, can exist. The beans act as a fallow crop, as well as nitrogen-collectors.

Peas are usually sown in February or March. They are sometimes, though not often, put in during autumn. There is a little difference in time, according to the variety: for instance, the field pea, with blue blossoms, is the earliest; then come the round blues and white peas, while the wrinkled peas are sown in April.

Peas may be sown broadcast, or with the seed-barrow. In the former method they are broadcasted upon a fine drilled surface, and harrowed in. This way, however, was found to encourage the growth of weeds, and led to peas being sown in rows, from twelve to fifteen inches apart, in order to allow of hoeing. They are drilled to a depth of two or three inches. After lea, peas are sometimes dibbled in, the holes being nine inches apart.

Owing to the difficulty of hoeing the land, from the spreading habits of the crop, peas are often sown with beans, in the proportion of one to two or three. The beans act as supports, and, as one crop is shallow-rooted, and the other somewhat deeper, they do not interfere with each other to any great extent.

The quantity of seed varies from two or three bushels drilled, to four or five broadcasted. Heavier seeding is practised in the north than in the south.

Heavy dressings of farmyard manure produce peas of coarse quality. Liming is said to improve the quality very much.

Turnips and Swedes are sown in late spring, and all through summer. Early white turnips may be sown in May, and early June; swedes in May and early June; white turnips and yellows in June and early July; late turnips in July, August, and early September. Both turnips and swedes are sown nearly a month later in the south than in the north. The reason for this is, that when early sown in the former districts they are much more liable to mildew.

There are three methods of sowing, *i.e.* broadcasting, drilling on the flat, and drilling on the ridge.

Broadcasting turnips has nearly gone out of fashion. When sown late, say in August, this plan may be followed, because the object being to produce as much food as possible during the short period of growth, drilling would give fewer number of plants per acre, and these do not reach any great development.

Drilling on the flat is practised chiefly in the south of England. The ground is first harrowed well, and then rolled. Then the seed is drilled in rows from fourteen to twenty-four inches apart. Two kinds of drills are used, viz. the dry and the wet. In the former, the artificial manures, mixed with the ashes of weeds, etc., are placed in a suitable receptacle, and are deposited with the seed. In the other, a tank takes the place of the box for manures. The fertilizers are dissolved in the water, and are lifted into the tubes by dredging wheels. In working this machine, from two hundred to eight hundred gallons of water are needed per acre. It has been found that during a droughty season the dry drills give best results. The other form encourages rapid

germination, but, after the temporary effects of the water have passed away, the young plants receive a severe check, which renders them very liable to mildew.

The ridge system is very suitable for the humid districts in which it is carried out. The width between the drills is usually twenty-seven inches, but it varies from twenty-five to thirty. The method of forming the ridges has already been given. The soil must be in a fine state of division for the operation.

The usual amount of seed is 3 lbs. per acre. Early turnips may need 2 to 3 lbs.; the ordinary crop does not require much more than 2 or $2\frac{1}{2}$ lbs. seed. When sown broadcast, 2 lbs. is sufficient. Owing to the plants being grown afterwards at wide intervals, only a few ounces are really needed to seed an acre of land. It has been found best to sow 2 or 3 lbs., as then there are more to pick from when singling, and the crop is not so readily destroyed by the turnip fly.

In manuring turnips and swedes note must be taken of the great benefit received from the application of phosphatic fertilizers. These root crops have very little power of absorbing the combined phosphoric acid of the soil, and hence superphosphate, or similar manures, are nearly always given. About ten or twelve tons of farmyard manure are ploughed into the land, and, besides, the following mixture may be given:—3 cwts. superphosphate, 1 cwt. bone meal, and $\frac{1}{2}$ to $\frac{3}{4}$ cwt. nitrate of soda. The superphosphate, bone meal, and a little nitrate are drilled in with the seed. The rest of the nitrate of soda is broadcasted soon after the leaves have appeared above the ground. In the north, a dressing of about 4 cwts. guano may be given instead of the above artificials. Owing to the caustic nature of this manure, it must be put in with the dung. Should no farmyard manure be given, a mixture of 4 cwts. superphosphate, 2 cwts. bone meal, 1 cwt. nitrate of soda, and 2 cwts. kainit may be used instead. The nitrate of soda is of use in hurrying the young plants past the smooth-leaf stage, when they suffer most from the attacks of the turnip fly. A large amount, however, may have an injurious effect, by producing a rapid growth at first, which is not kept up when the artificial supply of nitrogen fails. A liability to mildew is the consequence.

The after cultivation of turnips is very important. On the ridge system, it briefly consists of (1) saddle harrowing, (2) stitch harrowing, (3) singling, (4) stitch harrowing, (5) stitch grubbing, (6) hand hoeing, (7) stitch hoeing. The first two operations clear away many of the weeds and loosen the soil. The singling begins as soon as the permanent leaf has fully formed. Most of the plants are pulled out, only the best being left, at intervals of eight to ten inches. This allows of their

greater development. There are one or two machines for this purpose, but the operation is nearly always performed by manual labour. The plants are removed either by means of a hoe, or by pulling out with the hand. From a quarter to one-third of an acre can be done in a day of ten hours. The workers, while pulling out the surplus plants, also remove the weeds. The remaining operations rapidly succeed each other, until the growth of the leaves prevents the implements working between the rows.

On the flat, harrowing across the rows is sometimes practised. Many plants are thus pulled out, and the singling, which soon follows, is rendered easier. After singling, the land is horse-hoed, and then hand-hoed, and may afterwards receive another horse-hoeing. In these operations great care must be taken that the horse-hoe does not go too near the rows, as in dry weather the stirring would favour the evaporation of water, and the consequent withering of the plants.

Mangels are about the first root crop sown. They should be got in during the latter part of March, April, and early in May.

The method of sowing is very similar to that of turnips; the flat and ridge systems being used in their respective districts. The width between the rows varies from eighteen to thirty inches. It is not desirable to have them wider than this, as the mangels would grow to a large size, but be very watery and of low feeding value.

The amount of seed used is 6 or 7 lbs. per acre. Each so-called seed is really a tough capsule enclosing three real seeds, one of which cannot grow, as a rule. The hard covering usually prevents germination to some extent, and, consequently, in order that it may be early, the seed is steeped. There are several ways of doing this. Thus the seed may be put in warm water for twelve hours or so; other farmers allow it to remain for as long as thirty-six hours in cold water. Others, again, use liquid manure. After this, the seed is allowed to dry some little time before sowing.

The manure for mangels is somewhat different from that for turnips. In this case phosphates do not produce such wonderful effects, but nitrate of soda acts very beneficially. The *Beta maritima*, from which the mangel originally sprung, being a sea-side plant, common salt may be given with good results. A common dressing for mangels consists of 10 or 12 tons farmyard dung (ploughed in), with 1 cwt. nitrate of soda, 2 cwts. superphosphate, and 4 or 5 cwts. common salt. The nitrate is given in two lots—one with the seed, when the superphosphate and salt are also drilled in; the other, with a little salt, is given a short time

before the last horse-hoeing. Instead of the above, if near the sea, give 10 to 12 tons farmyard manure and 6 to 8 tons seaweeds, with perhaps 2 cwts. superphosphate drilled with the seed. When no farmyard manure is given, apply 2 or 3 cwts. superphosphate, 1 cwt. bone meal, $1\frac{1}{2}$ cwts. nitrate of soda, 2 cwts. kainit, and 5 cwts. salt. Mangels, it must be remembered, are very rapid growers, and take up comparatively large amounts of the plant-food constituents of the soil.

The after cultivation on the ridge system is much the same as for turnips. The land is first saddle-harrowed, by which means two stitches are cleaned at a time. About a week after this, they are stitch-harrowed between the rows. The stitch grubber is next used, and then singling commences when the plants have a fairly strong leaf. The distances between the mangels left should be between twelve and sixteen inches. It should be noted that, if a blank place occurs, some of the young plants pulled out from other parts may be put in to fill the vacancies. After this the land needs an occasional working; generally two grubbings, a stitch-harrowing, and a hand-hoeing are given.

On the flat, a horse-hoeing is adopted when the plants are high enough. The work for the first time should be done in the early morning, if possible, as soon as the rows can be clearly seen. Care must be taken not to go too near the plants. Little more than the surface soil will be stirred on the first occasion, but at each succeeding hoeing the cultivation becomes deeper and deeper. After the first horse-hoeing, the crop is roughly hand-hoed, then horse-hoed again. Thinning now commences, and is followed by horse-hoeing, and then the operation is repeated by hand. After the hoeing has been done about three times in both ways, the leaves will have met across the rows, and further cultivation is unnecessary.

Carrots are sown in the end of March or beginning of April, the former time being preferable. Before sowing, the land is harrowed and rolled in dry weather, and then the seed is drilled in with the manure. When on the flat, there is from fifteen to eighteen inches between the rows; sometimes, though not very often, they are grown in raised drills twenty-seven to thirty inches wide. The wide raised drills allow of the land being more easily and thoroughly cleaned; usually two rows of seed are sown in the same drill.

The amount of seed per acre is eight or ten pounds. Like that of mangels, it may be previously steeped in water to secure rapid germination. The hairy character of the seed causes it to cling together, and gives some difficulty in drilling. To prevent this, it should be rubbed up with two bushels of dry sand or earth.

The seed must not be covered in drilling to a greater depth than one inch. It should be harrowed in. Owing to the small and finely divided character of the leaves, they are difficult to hoe, and soon become overgrown with weeds. Hence a small amount of oats are often mixed with the carrot seed. The oats show the position of the drills and allow of easier hoeing.

It has been recommended to sow alternate rows of mangels and carrots, as the crops in no wise interfere with one another. In Belgium, carrot seed is sometimes broadcasted over the young rye in spring, and harrowed in. The rye is cut in June with a cradled scythe, care being taken not to injure the tops of the young carrots. After clearing off the stooks, the land is harrowed, and then receives a dressing of liquid manure. No further cultivation is needed until the crop has to be taken up.

In the ordinary way, the hoeing goes on just the same as for other crops. The thinning takes place when the plants are from one to three inches high; the intervals between them vary from four to eight inches.

Parsnips are sown in February or March. The amount of seed per acre is six to eight pounds per acre, usually mixed with a little oats or turnip seed. They are sown in much the same way as carrots, and need very similar cultivation. The plants are singled out to six or eight inches apart.

Cabbages are generally raised by transplantation. A piece of vacant ground in the corner of some field is ploughed, dunged, and harrowed down fine. The seed is then drilled in rows from nine to twelve inches apart. The period for doing this commences about the middle of July, and finishes about the second week in August. From one to two pounds of seed may be sown for every acre to be transplanted, and for this amount a plot of sixty square yards will be needed. A dressing, equal to 3 cwts. superphosphate per acre, may be drilled in with the seed. By October the young cabbages will be large enough for transplanting. The rest of the land has been previously got into a fine state of division, and drills are marked out from twenty-four to thirty inches apart. The latter distance, rather than the former, should be employed. The plants are drawn from the seed-bed and put into their fresh positions with as little delay as possible. Dull showery weather is preferred for the operation. The roots of the young plants should be dipped in the puddle of the dung heap before transplanting. Planting is usually done with a dibble. A man makes a hole, inserts a plant, and then presses the earth firmly round it. Some people prefer to make the hole with a spade. The plants are about twenty-seven to thirty inches apart in the rows.

Transplanting is very often left till March or April, the

following year. Drumheads may be sown in March, and planted out in May or June.

When the plants are firmly rooted again they may receive one to two hundredweights nitrate of soda. About one hundredweight per acre may be dropped around the stems of the plants as a first dressing, and then another hundredweight may be broadcasted over the land before they are finally earthed up.

The crops are first flat-hoed, then horse- and hand-hoed. These last two operations are repeated as many times as necessary to keep the land clean. About the end of July a double-mould-board plough passes between the lines, so as to throw the earth up on the rows.

Kohl-rabi.—The seed may either be sown on the flat or on ridges like turnips, or the plants may be raised in seed-beds, and then transplanted into rows, twenty-five to twenty-seven inches apart, with ten to sixteen inches distance in the lines. When the latter method is adopted, from ten to sixteen ounces of seed are sown in rows about twelve inches apart. The seed-bed needs to be well-prepared, and requires to be about thirty-six square yards in area. The seed is not all sown at the same time; it may begin in March and continue, at intervals, up to the end of May or early in June. The plants remain at least two months in the seed-bed, and are transplanted when about eight inches high. They are dibbled in the same as cabbages, and as the earlier ones will have more time to grow, they are at greater distance apart than the later-sown plants.

Some authorities, however, say that the heavier crops can be obtained by ordinary drilling, which also saves the trouble and cost of transplanting. The crop is sown in the latter part of April or early in May; from two to four pounds of seed are required per acre.

The land must be in a fine state for the seed, and may receive a dressing of dung. Nitrogenous manures should, however, be always given. Two to four hundredweights of Peruvian guano and sulphate of ammonia or blood-manure should be broadcasted over the land after it has been grubbed, and then harrowed in.

When drilled, the plants need to be thinned out to distances of from ten to fifteen inches. They are hoed similarly to root crops.

Rape.—The earliest seeding is in April, but the main crop is sown in June, and small patches may be put in afterwards.

The land is well dunged and tilled, and the seed is sown on the flat in rows, about fifteen inches apart. Four or five pounds of seed is the usual amount. Rape may be sown broadcast, ten or twelve pounds of seed being required. It can also be transplanted. In order to get the largest yield, thinning should be

practised, the plants being left twelve to fifteen inches apart. Though this operation is sometimes performed, it is generally roughly done, and very often the crop is left to grow all together. The intervals between the rows may be horse- and hand-hoed, so as to keep the land somewhat clean.

Besides dung, rape may have three or four hundredweights of superphosphate drilled in with the seed.

Vetches may be broadcasted over rows of rape, and the two will form an excellent food for sheep.

Kale may be sown direct or transplanted. In the former case it is sown in April, at the rate of four or five pounds per acre. A small amount may be sown in August, for feeding in late spring. Transplanting is said to give the best crops. The seed is sown early in August, and transplantation goes on during October and November. The land needs to be well-prepared, and gets a heavy dressing of dung. A top-dressing of nitrate of soda, dropped around each plant, gives good results.

Potatoes.—The early varieties are planted in February and March; the later kinds in April.

When the land is heavy the farmyard manure is sometimes applied in the autumn, but the common method is to raise the land in ridges and apply the manure between them in the spring. The seed potatoes are then planted, usually by women, at distances of ten to fifteen inches, according to the variety. All or part of the artificial manures may be sown at the same time. The ridges are then split by the double-mouldboard plough, and thus the whole is covered in within a few hours of planting. It is often the rule to have the ploughs opening drills one way, and closing them on return. A considerable staff is needed to keep the work in full swing. We may reckon on having two men and four horses to open and close drills, two boys and four horses carting manure from the dung-heap to the drills, two men filling carts at dung-heap, one man emptying the carts, six women spreading manure in the drills, six women planting sets, one man sowing artificial manures. This is a total of five men, two boys, twelve women, and eight horses. From four to five acres can be finished daily. The machines for potato-planting are not often used.

On the flat, a fine seed-bed is obtained in spring by means of grubbing and harrowing. Then the land is ploughed with a turn-wrest plough, and the sets are planted in every third furrow from nine to fourteen inches apart in the rows. Another method is sometimes pursued, for which more manual labour is required. A man walks across the field, making holes at the proper distances with a spade. A boy following drops a set into each hole. As they return, the man makes a fresh line of holes, and also fills

in the last row. Again, the potatoes may be dibbled in. A hole is easily made, then a potato is dropped in, and the hole closed.

The lazy-bed method is pursued much more commonly in Ireland than in the other parts of the British Isles. The usual method is to mark off the ground into beds four or five feet broad, between which are trenches one and a half to two feet wide. A dressing of dung is spread over the beds, and the potatoes are then planted on the surface. Earth from the trenches is laid over the dung to a depth of three or four inches; and as the size of the plants increases, more earth is spread over them. The advantages of this system are (1) that the trenches act as good drains, and (2) by shifting the position of the trenches each year the land is thoroughly dug up to a depth of two feet or more.

The seed of the potatoes is not a suitable means of propagation, as the plants which grow from it cannot be relied upon. Some may be good, but many are the reverse, and the plants grown are seldom exactly the same as the parents. The tubers, which are swollen parts of the underground stem, are used instead. They are kept stored up in some dry place through winter, and, while the land is being got ready for the "seed," they may be sorted. All soft ones should be thrown to one side, as well as others that are suspicious in any manner. As very small potatoes produce puny plants, they may be separated into two lots by means of a 1¼-inch riddle. The small are rejected, and the rest are dressed by means of a 1¾-inch riddle. Those which pass through may be used as they are; the others are cut up into proper sets. Cutting the potato, if properly done, does not prevent it in any way from producing a good plant, and by this means fewer potatoes will be needed per acre. The potatoes for cutting must, of course, not be below medium size, as small sets give poor results. The "rose" end only should be used, as the sprouts from the "heel" end are weakly. It is necessary to leave at least two eyes in each cutting. It has been found that from the eyes groups of fibres ramify through the substance of the potato toward the point where the root enters at the "heel." These bundles of fibres should be left as intact as possible in each set, and hence, after removing the "heel" half, the remainder should be cut lengthwise into sets. The cut sets should not be kept too long before planting, but some of them, at least, must be stored some little time. It is, indeed, advisable to keep them all a day or two before planting, as a thin crust forms over the incised surface, which prevents their decay to a great extent in the soil. If to be kept any length of time, a dusting with lime has been recommended. By forming a crust, it prevents the exudation of sap.

M. Girard has found that medium-sized potatoes, planted whole, give much better results than either small potatoes, planted whole, or large ones cut into sets. This result has been confirmed by numerous English and Scotch experiments.

In order to secure early growth, the potatoes are often sprouted before planting. For this purpose medium-sized potatoes may be placed whole in wooden trays. These are piled up in some fairly warm, dry place, such as the cattle byre. Two or three inches of a tough blue stem are developed from the eyes, and consequently, after planting, which needs some care, the crop is already growing. Nourishment is stored up more rapidly, and early maturity results. A fortnight or three weeks will make a vast amount of difference between the selling price of early potatoes. The seed tubers, when stored in pits, should be turned towards the end of February, to prevent excessive sprouting. Although a little is to be desired, too much will exhaust the potato.

The amount of seed varies from twelve to fifteen hundredweights, according to the kind. When sprouted, this quantity must be increased a little.

A crop of eight tons of potatoes removes from the soil—

Nitrogen	63 lbs.	=	4 cwts. nitrate of soda.
Phosphoric pentoxide	28 ,,	=	2 ,, superphosphate.
Potash (K_2O) ..	102 ,,	=	2 ,, muriate of potash.

As the crop is usually sold off the farm, the land may be said to have lost these amounts of fertilizing constituents. From fifteen to twenty tons of farmyard dung may be applied, with 1 cwt. superphosphate, ½ cwt. bone meal, and ½ cwt. muriate of potash. Should no farmyard manure be given, 2 cwts. superphosphate, 1 cwt. bone meal, 2 cwts. Peruvian guano, and 2 cwts. kainit, or 1 cwt. nitrate of soda, 1½ cwts. dissolved bones, 3 cwts. superphosphate, and 2 cwt. kainit may be applied.

The after cultivation consists of as many horse- and hand-hoeings as are needed to keep the land clear of weeds. These operations are commenced as early as possible, and are kept up until the tubers are ripe. When the tops are eight or ten inches high, the rows are earthed up. For this purpose the double-mouldboard plough is most suitable, though the hand-hoe can be used.

Clover and Seeds.—Rotation grasses and clovers are usually sown upon a corn crop about April. In the Norfolk rotation the corn crop selected is barley, but in the Northumberland they may follow wheat or oats. No preparatory cultivation is made specially for the seeds; they are distributed over the surface with the broadcast barrow when the foster-crop is a few inches high. They

may then be harrowed in with a very light seed harrow, care being taken that the seed is not buried deeper than half an inch. The horse-rake may be used instead. A seed-drill is sometimes employed, but is not so good. After the drilling, the land should be rolled. It is not advisable to sow the seed before the corn crop has appeared above the ground. In some districts seeds are sown in August without a cereal crop, the ground being well cleaned previously.

The kinds and quantities of the seeds of various grasses sown depend upon the number of years they have to lie down, and the character of the land they are grown upon. For a one-year mixture only those plants must be taken which are at their best during the first year. After this they will become more and more permanent. For one year's lea we may take 14 lbs. Italian rye-grass, 2 lbs. timothy, 2 lbs. cocksfoot, 8 lbs. red clover, 3 lbs. alsike, 3 lbs. yellow clover. For two years' lea use 10 lbs. Italian rye-grass, 5 lbs. perennial rye-grass, 2 lbs. timothy, 4 lbs. cocksfoot, 2 lbs. meadow fescue, 1 lb. meadow foxtail, 4 lbs. broad red clover, 2 lbs. perennial red clover, 2 lbs. alsike, 2 lbs. white clover. For a three or four years' lea the following mixture is suitable:—12 lbs. perennial rye-grass, 5 lbs. Italian rye-grass, 5 lbs. cocksfoot, 3 lbs. timothy, 2 lbs. meadow fescue, 2 lbs. meadow foxtail, 3 lbs. perennial red clover, 2 lbs. alsike, 3 lbs. white clover, 2 lbs. yellow clover.

When clover and grass seeds are sown with a broadcast barrow, it is usually necessary to perform the operation in two parts, the two kinds of seeds being sown separately. If this were not done, the heavier character of the clover seed would cause it to run out more quickly, and an uneven seeding result. With the cup-drill the two can be sown together.

In the Norfolk rotation, the clover will be grazed by sheep through the next spring and summer, and is broken up for wheat in August or September.

In the Northumberland five-course, the mixtures contain more grass and less clover seeds. During the first year it is mown, and then the aftermath is grazed. Through the winter the land carries little or no stock, but is again grazed in spring, summer, and following winter, being ploughed up for oats in January and February.

Vetches are usually sown in breaks, so that a succession of food may be had. The first sowing may take place as soon after harvest as possible; the next may be in October, and afterwards in November; then in early February, and up to May, or even later.

The amount of seed varies from $2\frac{1}{2}$ to $3\frac{1}{2}$ bushels per acre.

It may be sown in rows eight inches apart or broadcast, and then harrowed in. It is a good plan to mix the seed with a little wheat, winter oats or winter barley. These support the vetches, which would otherwise creep along the ground, and thus often cause the lower part of the straw to become rotten.

Vetches are not always manured, but sometimes get a light dressing of farmyard manure, which should be allowed to lie on the surface for a few weeks before ploughing in. A top-dressing of $1\frac{1}{2}$ cwts. Peruvian guano is given by some farmers. Three or four hundredweights of kainit gives good results; it should be applied before the seed.

Vetches are at their best for feeding when in full flower, but, as the period during which they are fed is usually prolonged, it is advisable to commence a little before this. The usual plan is to fold sheep upon them, enclosing a sufficient area by means of hurdles or nets. Instead of this method, the vetches are often mown daily, and fed to the stock. The crop is available from April to October, when suitably sown.

The produce per acre is ten to fifteen tons green fodder, or twenty-five to thirty bushels of seed and a ton and a quarter of straw.

Trifolium is sown in August or early in September. The seed is sown at the rate of twenty pounds per acre, by means of the broad-casting barrow, and is then harrowed in well. After this the land is heavily rolled, preferably with a Cambridge roller. This crop requires a firm seed-bed, with shallow-surface cultivation. Instead of sowing trifolium alone, Professor Wrightson recommends a mixture of 16 lbs. trifolium, $\frac{1}{2}$ bushel of winter vetches, and $\frac{1}{2}$ bushel of winter oats.

Trifolium is excellent spring forage, and is disposed of in a similar manner to vetches. It may be made into hay, but it is better not to do so if possible, as it is too stemmy. After one cutting, the land is broken up and turnips may be taken.

Trefoil.—Twenty pounds of seed are sown with the broadcast barrow upon the young corn. It is then covered by gently harrowing or rolling. The produce may be cut in April or May, and cleared away in time for a crop of turnips. It gives a very fine, sweet hay, though the yield is only low. The proper place for trefoil (or yellow clover) is among mixtures of clover and seeds.

Italian Rye-grass may either be sown alone or in mixtures. Not being perennial, it may be excluded from permanent pastures. It is well suited for sewage meadows, and then yields very heavy crops, as much as sixty tons per acre of green fodder being sometimes obtained. The amount of seed per acre, when

sown alone, varies from two to four bushels; but, in mixtures, less than one bushel is the proper quantity. Two methods of seeding have been recommended. One is to sow it broadcast over the young wheat in April; the other is to sow it on part of the fallow land in August, and up to the middle of September. There is not much to choose between the two ways, but the first is the simplest, and allows the plant to get a firmer root before winter.

Rye-grass is sown by hand, or by means of the broadcast barrow. When sown on a corn crop, gently harrow the surface, put in the seed, and roll or harrow it in. When sown without another crop, the land is dunged and worked to a fairly fine tilth. The seed is broadcasted and harrowed in.

Italian rye-grass will stand very heavy manuring. On the sewage meadows several cuttings are obtained each year. Nitrate of soda causes a rapid development of the crop.

The produce of hay per acre varies from one to two tons. Thirty bushels of seed are obtained, but scarcely any farmers take the trouble to secure it.

Sainfoin.—The land needs to be clean and in good condition. The seed is sown down upon barley. It may be mixed with the cereal crop and drilled with it, or it may be drilled separately across the other rows, in lines six or eight inches apart. Another method is to broadcast it soon after getting in the barley. A harrowing should then be given. The amount of seed per acre varies from four bushels of the rough seed (in the pod) to fifty-six pounds of milled (clean) seed. As only a poor crop of sainfoin is obtained the first year, about six pounds of trefoil are often mixed with it. The treatment is very similar to that of the clover crop; the first year it is mown for hay, and afterwards it is grazed. Old sainfoin gives a very good run for sheep, and the hay is also of good quality. To secure the latter at its maximum value, it should be cut before flowering. About two tons are obtained per acre; the yield of seed may be taken at thirty bushels.

As sainfoin gets old it gradually becomes overrun with such weeds as couch-grass, etc., and to prevent this it is usually broken up in its sixth or seventh year. Sainfoin should not be grown upon the same piece of land oftener than once in twenty years.

After breaking up the land, it is usual to take a crop of turnips, as wheat would get very weedy, and probably be attacked by insect pests, wireworm, etc.

Lucerne is sown in April, so as to give a cutting in the following autumn. It is drilled upon a fine, rich seed-bed, in rows nine to twelve inches apart. The land must be clean, and should be well dunged previously. The amount of seed is ten to twenty

pounds per acre. The ground must be kept clear of weeds by repeated hoeings—best performed when the soil has been moistened by rain. During the first season only one, or, at most, two cuttings are obtained; care being taken that the plants are not mown down too near the ground. After this it may be cut three or four times each season; the produce is very often used for soiling. Twenty to thirty tons of green fodder are obtained each year.

The crop is usually ploughed up in its fourth year, as it gets full of weeds.

Lupines.—One to two bushels of seed is drilled in rows, fifteen inches apart, during May and June. It may be cut for fodder in the end of July, when about to flower, or it may be left to seed. Lupine-seed meal is excellent for young calves. The produce amounts to fifteen or twenty tons green fodder, or twenty-five bushels seed.

Gorse may be sown at the rate of twelve to fifteen pounds per acre, in rows at least one foot apart, during March. The young plants are kept clear of weeds by hoeing, and a cutting will be obtained in the autumn of the second year. Some varieties do not grow well from seed, and are raised from cuttings. These are transplanted into rows eighteen inches apart, with eight inches in the lines. The cutting is performed by means of a heavy hook; the produce is often tied up into bundles of twenty pounds each. As the cutting takes place every second year, it is advisable to cut every alternate row annually. Thus, some will be ready each season. The crop equals about twenty tons per acre, and is perennial.

Before feeding to stock, gorse needs to be bruised.

Prickly Comfrey is usually propagated by means of cuttings. These are dibbled in, in rows two or three feet apart, and with one and a half to three feet in the lines. The work is performed during spring. Another plan is to sow about six pounds of seed upon oats in March or April. The land needs to be manured heavily, and the intervals are kept clean by the horse- and hand-hoes. From six to eight cuttings yearly are obtained after the first season, and the produce will amount to forty or fifty tons.

Mustard.—The usual seeding is a quarter of a bushel, sown broadcast in the end of April. The white mustard will be ready for folding sheep early in July.

The brown mustard needs to be kept clean by hand-weeding, but otherwise the two are cultivated on much the same lines.

Maize may be sown at wide intervals, in rows one and a half feet apart. The seeds are dibbled in upon well-prepared and dunged land, some time between the middle of May and the

beginning of June. The plants may need singling. The crop is cut green about August.

Hops require very careful cultivation. The land is first trench-ploughed, and receives a dressing of farmyard manure. The hop plants are raised from cuttings, which are taken from the "hills" early in spring. They are then reared in a nursery until the autumn, when they may be planted out. Planting also takes place in early spring. The cuttings are then inserted in rows about six feet apart and six feet distances in the rows. There are two methods of planting, *i.e.* either in square or quincunx order. The latter is preferable, as more plants can be grown per acre, and the horse-hoe can be worked nearer to them. Three cuttings are usually planted together on a hill.

As there is usually no produce the first year, the spaces between the rows may be planted with cabbages or some other such crop.

The land must be kept quite clear of weeds, and should be heavily manured. In the spring of the first year the bines are tied to poles, one being stuck in the middle of each hill. In the following spring the ground is dug and manured, and three poles are given to each hill. The poles now given are much longer than the former ones. The best are of ash or chestnut, and are from fifteen to eighteen feet long. They are placed at equal distances around the hill, and must be firmly inserted. The three best bines are fastened to their respective poles by means of rushes. The binding continues from near the ground to about five feet high. The remaining bines are cut out and cleared away.

The intervals between the hills are hoed by means of the "nidget," a kind of horse-hoe. Nearer the bines themselves, hand-hoeing may take place. In June the hills are earthed up with the spade, and a little pruning may be done about the same time. Picking proceeds as soon as the crop is at the proper stage of ripeness. After picking, the poles are stored away through winter, in conical piles. During autumn the land is dug up, usually with the "spud," which is a three-pronged fork. Early in spring the old bines and superfluous growth are cut down and removed, and then the poles are inserted again.

Hops need very heavy manuring. A dressing of farmyard dung and shoddy is usually given in autumn or early in spring. The rate is at about twenty tons farmyard manure, and from half to one and a half tons shoddy or other wool waste. During summer some artificials are usually applied. Six hundredweight superphosphate is a common dressing; or guano, blood manure, rape dust, etc., may be used.

As the hop is a diœcious plant (that is, some are males and others are female), both kinds need to be planted. The males are simply used to fertilize the others, and are planted in the proportion of one to ten. They yield no marketable produce.

Flax is drilled or broadcasted late in March or early in April, at the rate of six to eight pecks per acre. It may be sown in rows nine inches apart, and is lightly harrowed in. The best seed comes from Riga. The crop is weeded during its growth, and comes into bloom in June. It is pulled any time after this. When grown for fibre it is not advisable to manure the crop. Flax is usually sown at intervals of about eight years; growing it more frequently than this on the same land is a failure.

Hemp.—From three-quarters to one bushel of seed is drilled in rows a foot and a half apart, in the end of April or early in May. The plants are afterwards thinned out to one foot apart. The crop is diœcious, like hops; the male plants are pulled out when seeding commences.

Buckwheat is sown late in May, either by means of the drill or by broadcasting. In the former case the rows are one to one and a half feet apart, and one bushel of seed is needed. When broadcasted, three bushels may be used. It does not all ripen at the same time, but should be cut when the largest amount is ready. About thirty bushels of seed per acre may be obtained.

Teazles.—Two pecks of seed per acre are drilled in during April, and then harrowed. This produces a large number ot plants, and, soon after the harvest, part of the corn stubble is ploughed up and cleaned. In October the teazles are transplanted from their seed-bed into the prepared field, being dibbled in, sixteen inches apart each way. The land is dug over several times with the spade during the following spring and summer, to keep down the weeds. The plant is a biennial.

Jerusalem Artichoke.—The tubers are planted in March, in rows three feet apart, and with eighteen-inches intervals in the rows. The cultivation is somewhat similar to that of potatoes. After one planting they produce crops year after year, the small tubers left in the ground when digging up the crop being sufficient for "seed." The quality of the produce, however, degenerates, and hence it is best to plant fresh every year or alternate year.

As the amount of seed sown may either be measured by the volume or the weight, we now give the weights per bushel of the seeds of some of our chief crops.

Cereals.—Wheat, 63 lbs.; barley, 55 lbs.; oats, white, 42 lbs., black, 38 lbs.; rye, 54 lbs.

Black Straw Crops.—Beans, $64\frac{1}{2}$ lbs.; peas, 64 lbs.

Root Crops.—Swedes, turnips, cabbages, and rape, 50 lbs.;

mangels, 21 lbs.; carrots and parsnips, 15 to 18 lbs.; kohl-rabi, 55 lbs.; potatoes, sets 45 lbs.

Fodder Crops, etc.—Vetches, 64 lbs.; trifolium, trefoil, and clovers, 64 to 66 lbs.; Italian rye-grass, 20 lbs.; sainfoin, 28 lbs.; lucerne, 60 lbs.; lupines, 62 lbs.; mustard, 54 lbs.; flax, 54 lbs.; hemp, 40 lbs.; buckwheat, 50 lbs.

3. Harvesting.

Some of our crops are not harvested at all; they are eaten off on the land by stock, usually sheep. Others may either be carted home or fed off on the lands; and some, such as the cereals, are always harvested.

The three cereal crops, wheat, barley, and oats, being almost identical as to their method of harvesting, may be well considered together.

Wheat, Barley, and Oats.

Harvest sometimes begins at the end of July, but August is the most general month for commencement. The work may be prolonged into September, and even into October in the north. The time for cutting depends upon the degree of ripeness and the kind of plant. Wheat and oats are cut before they are fully ripe; barley, after it has become so. The reasons for cutting wheat and oats at such a stage are:—

1. If left till too mature, the bran thickens at the expense of the grain. Woody fibre forms in the straw and bran.

2. The value of the straw for feeding purposes is decreased. Indigestible lignin forms, and the greater part of the food constituents are carried upwards to the ear.

3. After the corn crop commences to ripen, it ceases to be dependent upon the soil for food, hence a larger crop is not obtained by leaving it long in the ground. After this point has been reached, there is simply a transference of materials from the straw to the grain.

Among the subsidiary reasons are:—

4. By early cutting the farmer saves risk from wind. It should be noted that it is the best and most matured grain that is lost in this way.

5. The risks from bad weather are less.

6. The land is cleared sooner. This allows it to be cultivated, and gives an opportunity of sowing some early fodder crop.

7. Over-ripe grain may sometimes sprout in the ear in damp weather.

Barley is left till it is very ripe, because in this way the best

coloured samples are obtained. The bran does not thicken as much as that of other cereals, and the grain is of better quality.

Wheat and oats are known to be well ripe when the head and a few inches of the stem beneath are of a yellowish colour. None of the grains will be milky, and the straw will contain no juice. Wheat, as it gets riper, gradually bends its ears down; the straw stiffens and the chaff opens.

Barley changes to a uniform yellow colour, and the head becomes stiff and does not move about so readily. It should be curved over, or sickle-shaped.

Wheat may be cut at two stages, (1) when to be kept, cut it fairly green; (2) if to be put straight into the market, cut when ripe. Dead-ripe wheat, after storing for nine or ten months, either has no smell or not a good one; that cut when greenish will have both a fine odour and flavour. When cut too early, the full produce is not obtained, and the grains shrink greatly in the stack.

The crops are usually cut by machine. Sometimes, however, some of it may become laid and twisted through storms, and it may then be necessary to cut it with the scythe or fagging hook. The machines may either be manual reapers, self-deliveries, or self-binders. The first is still in common use.

The process commences by cutting round the borders of the fields with the scythe—"opening out," as it is called. This leaves a passage for the machine, which may now commence cutting, provided the weather be fine enough. There are two methods of working: one is to cut right around the field, the other to only cut one side. The latter way is, of course, slower, as time is lost on the return journey. It is, however, often the only practicable plan when the crop is laid in one particular direction.

The action of the machines has been discussed in the part on "Agricultural Engineering."

The process of binding, if not done by the machine, requires a fairly large staff of workers. Each should bind from three to five roods per day. They may be given a certain number of sheaves to bind or a certain distance to go over. Sometimes lads are provided to make bands for the binders, but each worker usually makes his or her own, lifts the sheaf, binds it, and then pitches it on one side out of the path of the machine. The bands are made by pulling out a handful of corn, and dividing it into two equal parts. The two are then laid across each other near the heads; they are held in the left hand, and then with the right the heads are twisted round so that they may lie above the twist. The sheaf is then laid evenly on the band on the ground, so that the twisted part of the band comes on the inside. The ends

of the band are pulled together and twisted as before; the end is then thrust under the rest of the band. As quicker work is done when the sheaves are small, it is not, as a rule, advisable to have them over eight inches in diameter at the band. With long clean straw that measurement may be increased to ten or twelve inches. Small sheaves dry better than large ones. The weight of a sheaf of wheat, ten inches in diameter, as it is cut, will be about twenty-five pounds.

When a large field is being cut, it is best to have two or three men stooking. They collect the sheaves, and place them in what are known as the stooks, or shocks. Two sheaves are first placed together butt-downwards, and then others are placed on each side, so that the stook consists of a double row of sheaves, five or six on each side, with two on the top. A proper stook should form a ridge which will shoot off all rain. The two sheaves on the top are not often put on for wheat, and it is not a common practice even for oats or barley.

In some cases, the men stay at night, after cutting has been stopped, and make up the stooks. The usual direction in which to place the stooks is from north-east to south-west, to get the sun and wind.

We shall now consider some of the peculiarities of the crops with regard to harvesting.

Wheat, having a clean straw, is the best crop to cut with the self-binder. For the same reason it is usually bound (by hand) in larger sheaves than barley or oats. Wheat should not be tied when wet, though some green weeds in the bottom are of no consequence. The stooks usually contain twelve sheaves, and seldom less than ten. At least a week is required by wheat to dry after cutting, and, as a rule, a longer time will be taken. If stacked earlier than this, it is apt to turn mouldy.

Barley, when ready for cutting, has a sickle-shaped ear, and the grain is hard, without colour, and the skin wrinkled into a fine network. If the weather can be depended upon, the best samples are obtained by allowing it to lie two or three days before binding. It is turned once or twice, and the exposure to the sunshine and dews produce a fine colour and mellowness of the grain. A heavy shower of rain might spoil the colour, and consequently in the north of England the barley is tied as soon as cut.

The stooks are usually smaller than those of wheat. As it is readily spoiled by rain, barley should be stacked as soon as ready and the carting of other grain crops should be stopped to allow the barley to be got in. If carted too early it readily heats in the stack, and may easily be spoiled this way.

Oats are more like wheat in their treatment. They take a

longer time to dry, and are never ready under ten days. If stacked when wet, they rapidly ferment and deteriorate.

The carting home of the crop follows as soon as possible. Waggons are the usual means of conveyance in the south of England. They will carry about twenty stooks each time, and therefore there are about four waggon-loads of wheat per acre. One-horse carts are used instead in the north, and take a little more than half as much as a waggon. Waggons will take, on an average, twelve loads per day, at an ordinary distance of half a mile.

The stacks are usually made on some bottom raised up off the ground. This will allow of ventilation beneath them. Some sheaves are piled up in the centre first, and then others are placed in circular rows around them. The stacks are usually of a diameter of from fifteen to eighteen feet. They should be evenly built up, and the sheaves should always slope downwards from the centre to the outside. In the north the stack is a little broader at the eaves than at the base. For a stack on a fifteen feet base, the height to the eaves should be twelve feet; after the eaves each layer of sheaves is taken in a little more than the preceding, so as to produce a cone.

After all the corn has been carried in, thatching commences. The process should be well done, and will cost about one shilling per hundred square feet.

COST OF HARVESTING.

1. *Cutting.*—(*a*) By the self-binder, cutting and stooking 10 acres per day :—

	£	s.	d.	
Six horses (working alternately in the machine) ..	0	15	0	per day
Machine and oil ; interest and depreciation on capital	1	1	0	,, ,,
String	0	17	6	,, ,,
Three men stooking, cutting, and binding round the field, etc. One man on machine	1	0	0	,, ,,
	£3	13	6	

= 7*s*. 4*d*. per acre.

(*b*) By the ordinary reaper, cutting 7 acres per day, and then stopping to allow the men to stook :—

	£	s.	d.	
Four horses	0	10	0	per day
Machine, oil, etc.	0	10	6	,, ,,
Man and boy, on machine ..	0	7	6	,, ,,
Six binders	1	10	0	,, ,,
Sharpening knives (five times)	0	2	0	,, ,,
	£3	0	0	,, ,,

= 8*s*. 6*d*. per acre.

After cutting with the ordinary reaper, the ground needs to be raked, unless women are employed to gather the sheaves. A man will rake about twenty acres per day, at a cost of fourpence per acre, and sixpence may be allowed for binding the rakings, thus bringing the total cost per acre to 9*s.* 4*d.*

2. *Leading and Stacking.*—About 14 acres of oats finished per day:—

	£	s.	d.
Two pitchers in the field	0	10	0
Four waggoners	0	18	0
Four waggons and horses	1	4	0
Two men and boy on stack	0	12	6
One forker in stack-yard	0	5	0
	£3	9	6

= 5*s.* per acre.
Total cost = 12*s.* 6*d.* to 14*s.* 6*d.* per acre.

Thrashing proceeds all through the winter, and may be done either by a fixed or a portable machine. The number of workers required varies a little, but the following list may be considered sufficient. One man to look after the engine and machine; one boy bringing water to the engine; two men pitching from the stack to the machine; one man or two women cutting bands, or two men for wheat; one man feeding the machine; one man looking after the sacking of the corn; one man carrying the corn to the granary; one man attending to the straw binder; one woman removing chaff; one man pitching straw from the machine to the stack; one man building the straw stack.

In a full day they will thrash by steam-power sixty quarters of wheat or a hundred quarters of oats. With the flail a man will thrash five quarters per day. The cost of thrashing is about 1*s.* 8*d.* per quarter.

As it is necessary that, for sale, grain should be as clean as possible, it is often dressed, after thrashing, with the winnowing machine. Barley, in particular, requires to be of a good even sample, and with this crop it will nearly always pay to pass it over a screen after thrashing. In thrashing barley, use is made of the hummelers to knock off the awns.

The tail corn is used for stock-feeding, as indeed nearly all the oats are. The proportion of dressed to tail wheat is as ten to one.

The produce per acre of wheat is 30 bushels grain and 30 to 33 cwts. straw, of barley 35 to 45 bushels grain and 13 to 20 cwts. straw, of oats 40 to 60 bushels grain and 20 to 40 cwts. straw.

Rye.—The harvesting, when for grain, is similar to that of any other corn crop. It may be cut in July, and yields 25 to 40

bushels of grain and 35 to 40 cwts. of straw per acre. The straw is very tough, and is excellent for thatching, but not for feeding purposes.

Forage rye may be cut or fed in April. It may be given to horses and cattle, chaffed with hay or straw. Sheep are the usual means of feeding it off.

Beans are cut as soon as the leaf has fallen. Another point to go by is that the pod should be yellowish and the eye of the bean black. If too ripe, the pods readily split and the beans drop out.

Reaping is commonly done with the sickle. The reaping machine also cuts a considerable part, but the knives get much injured by the hard stalks. When done by the former method, they are cut with a heavy sickle known as the fagging or bagging hook, and which has finely serrated edges. The operation is performed thus—The workman, holding back the stalks with his left arm, strikes at the stems near the ground, and driving the cut stalks up against the standing corn. He thus advances across the ridge until he has collected sufficient for a bundle. He then gathers it together with his hook and left hand over his left foot as he walks backwards, and finally lifts it on to a band laid before he commenced cutting. The bands are usually of straw, and are tied by a woman as the reaper cuts another bundle.

When the beans are short and growing near to the ground, it may be necessary to pull them up. Both fagging and pulling are very slow operations.

Beans are sometimes left lying unbound for a few days after cutting. After tying, they are set in stooks of four to six bundles each. They require to stand for a considerable time, and should be well dried; but after they have become dry, a shower of rain, unless very heavy, need not stop carting. They are left in the stack for a long time before thrashing.

The produce per acre is 25 to 40 bushels, with 25 to 30 cwts. straw.

Peas are cut as soon as the pods and straw change to a brown colour. The cutting is done with the pea-hook, scythe, or machine. The last two are unsuitable, as they are apt to cut open the pods. The trailing stems make the operation in any case difficult. Peas are not bound as cut, but are left in small heaps, called "wads," to dry. These bundles are turned over several times, and, when dry enough, they are rolled up into oblong form and bound with pea-straw. They may then be set up together in the form of stooks, or left to lie separately. When dry they are carted and stacked. This operation needs care, as the pods easily crack and let out their contents. Pea-stacks are

not only thatched on the top, but the sides are also often coated with straw.

When thrashing peas, great care must be taken that they are not split, and, to prevent this, it is often necessary to take the steel bars off the beaters of the thrashing-machine.

The produce per acre is 30 to 40 bushels of seed and 25 cwts. straw. The straw is very nutritious, and a capital food for dairy cows.

When peas and beans are grown together, the crop is usually tied up by means of the pea-haulm.

This concludes the harvesting proper, but we must also notice how the root and fodder crops are dealt with.

Turnips and Swedes are either fed off on the land by sheep, or are carted home for use in the byres, etc. When the fields are some distance from the steading the former plan is preferable. It saves much cost, both in carting home the turnips and carting back the farmyard manure. Some information upon feeding off roots, and the necessary precautions, will be found in the article on sheep management in "Live Stock." The method of carting home entails the trouble of lifting the roots, and then of topping and tailing them. This operation consists of cutting off the roots and leaves (to within an inch of the crown) by means of a knife. The bulbs are now thrown into rows, four ridges commonly going into one of these rows. This renders the carting easier. They are usually stored in long prismoidal heaps of triangular section, and covered over with several inches of refuse, straw, and earth. A shallow trench is then dug around the heap for drainage.

The produce of bulbs per acre is—Swedes, 12 to 30 or even 40 tons; yellows, 18 to 25 tons; whites, 20 to 25 tons. The crops of swedes in the north are often twice as large as those in the south, or even more than that. Weight of bulbs per bushel, 42 to 45 lbs.

Sometimes, though rarely, except with seedsmen, part of the crop is saved for seed. The turnip is a biennial plant, that is, comes to flower in its second year. Occasionally, through bad seed, forcing manure, etc., they may do so during the first season, but are not then to be relied upon. The operation is as follows—A few loads of the turnips are removed to a corner of the field in September or October, and covered over with loose strawy dung. The rest of the field is well tilled and heavily manured, and the turnips are transplanted again in February. They are kept very clean, and soon send up long flower-stalks, which in the case of white turnips may be cut in July, and swedes towards the end of that month. They are cut in small bundles, which are not bound, but are laid on the ground for three weeks or a month to

ripen. They need to be frequently turned, and this must be done early in the morning when the dew is on the ground, to avoid all spilling of the seed. When thoroughly ripe, the bundles are carefully pitched into carts with side-boards, and carried to a large sheet placed in a horse-shoe shape. The bundles are arranged, butts outward, on this, and then a roller is dragged across until the seed is all knocked out. It is scooped up, and passed through sieves to clean it. A fine dry day is needed for the thrashing, and the cultivation all through is risky, as stormy weather knocks out most of the seed. The produce varies. Swedes will give 28 or 30 bushels; yellows, 20 bushels; whites, 20 to 25 bushels. In bad seasons only 6 or 7 bushels may be got.

Mangels differ from turnips in not being eaten off on the ground. If fed in autumn, they cause the animals to suffer from scour, owing to the acrid substances they contain. When stored till spring much of these change into sugar.

The crop is ready for harvesting in October. The mangels are best pulled up by hand, and the leaves wrenched off. The rootlets are left, and it is not advisable to use a knife to dress them with at all. If they are cut or bruised, the juice is constantly exuding, and the interior soon rots.

Mangel heaps are of the same shape as those for turnips, and may be made with a base of six feet and height four feet, or in those proportions. The mangels are covered over with a layer of refuse straw six or ten inches deep, and on this earth is piled, except along the ridge, which is kept bare for ventilation. A trench is dug around. Mangels come into use after swedes.

The cost of pulling, topping, and tailing is about seven shillings per acre; building and covering clamp, four shillings; total, with carriage, about £1 per acre.

Produce per acre: twenty to thirty tons of bulbs is the common rule, but crops of seventy or even one hundred tons are sometimes obtained in the south of England. Seed, sixty bushels.

Carrots are also unsuited for feeding off on the land. They are ready for lifting about the end of October. The lifting is a laborious task, and is performed with the aid of a fork, having two or three prongs, each about a foot long and three inches apart. This is thrust deeply into the soil behind the root, and, by using it as a lever, the carrots can be raised without injury. The tops are then cut off. Taking up the crop is expensive work, and will cost from about ten to nearly thirty shillings per acre. If the weather be fine, the roots are all the better for lying a few days in the field to dry. They are then packed in clamps, similar to those of mangels, but of rather less size. The heaps are built with the crowns of the carrots outwards and the tails towards the

centre of the heap. They are covered over with straw and earth. Good ventilation is necessary, and this may be provided by using drain-pipes in the top of the heap.

The carrot leaves may be kept for the cattle, which relish them very much.

Produce of roots, ten to twenty tons per acre. Weight per bushel, forty pounds.

Parsnips are harvested similarly to carrots. They are not so liable to injury by frost, and can be left in the ground a longer time before pulling. They give eight to fourteen tons of roots per acre.

Cabbages arrive at maturity about the end of October. If left out longer they get injured by the rain and frost. They may be either cut or folded. For the latter purpose sheep may be put on the land in late June or July. As a rule, however, the crop is cut or pulled out by the roots. If the land is wanted immediately the latter plan is best, but, if the crops are left, a second crop is obtained. To produce a good second crop, the best plan is to cut out the heads, leaving three or four bottom leaves.

Cabbages are not a very suitable crop for storing, and are best fed green, being especially valuable for milch cattle. They may be made into silage. The best plan for storing cabbages is to throw up a "land" with the plough, and make it hard on the top. Spread a layer of straw, and lay the cabbages upside-down on the straw; cover over with straw and a little earth. Other methods are to replant them in a sloping manner and cover with straw; to bury the heads in the soil and leave the roots in the air; to hang them up by the roots in houses, etc., but none of these plans are very successful.

The crop amounts to thirty or forty tons heads per acre. If allowed to flower, about thirty bushels of seed may be obtained.

Kohl-rabi, owing to the bulb being developed above ground, can be fed off on the land with minimum waste. As they are very hardy, they may be left till spring, and then eaten off by sheep. They may be stored in the same manner as turnips, first stripping off the leaves, which are themselves good food.

The produce per acre is twenty to twenty-five tons of bulbs.

Rape will be ready for forage purposes about September, though some may be fit for folding in August. Rape is usually fed off on the land by sheep. A second crop may be obtained by preventing the flock from eating the stumps. This later produce may be almost as bulky as the first, but is very watery and of low feeding value. Still, in very dry weather, or when allowed to stand till spring, it may be useful food.

The produce of green food is ten to twenty tons per acre.

Rape is sometimes cultivated for its seed. It is then sown in

July and August, and tilled as when grown for fodder. It is thinned more carefully, and is ready to cut next July. It is bound into sheaves, allowed to dry, and then thrashed out on a sheet in the field. The yield of seed averages about thirty bushels per acre. It is used for making rape cake and oil.

Kale is ready for folding in July and August of the following year. When sown in April, however, it may be fed off in the same autumn. There are two methods of using it. One is to feed it off on the land with sheep, taking care that they do not eat it so close as to injure the stems. If this point be attended to, another crop will be obtained in the following April. The other plan is to cut the heads, leaving three or four bottom leaves. The heads are then carted off for feeding on the pastures or in the byres. The second method gives better crops but is more expensive.

Potatoes are ripe when the leaf begins to fall and decay. Early potatoes are dug as soon as they are of large enough size, but they will not keep well so long, as the skin can be readily rubbed off with the fingers.

In order that early potatoes should not be so much bruised, they should be raised with the graip. The potatoes as they are dug out are sorted by women, and collected in willow baskets. They should be marketed as early as possible.

The ordinary varieties may be lifted with the fork, the plough, or the potato-digger. The second is a very common method. There are now ploughs made specially for this purpose, but the ordinary form, with the raiser attached, may be used. The latter consists of a series of iron or steel fingers attached to either one or both sides of the body. In the north, at least, the double-mouldboard plough is very often used for raising potatoes. The mouldboards are set wider than usual, and every other drill is opened. A set of workers clear out all potatoes, and after a while the ridges which have been left, are opened.

The potato-digger is a very useful machine, where it can be used, but it is not suited for stiff land. From two to five acres can be finished per day with it, and the machine usually requires three horses. A large staff of workers are required to keep the work in full swing; from twenty to thirty will be needed, according to the size of the crop and amount of disease present.

After the plough or the digger has been over one section of the field, a light harrow with long tines should be sent over it. This exposes any potatoes left, and also levels the land greatly.

An ordinary crop amounts to from six to nine tons per acre; early potatoes, four to six tons. Weight per bushel, fifty-three pounds.

Large quantities of potatoes are usually stored in pits in the

open field. Shallow trenches, one yard wide and nine to twelve inches deep, are dug in dry sandy soil, but if the land be clayey or at all wet it is not advisable to make trenches. The potatoes are heaped up in the form of long triangular prismoids, as with turnips and mangels. The heap is not, as a rule, wider than four feet. When the heap is completed it is thatched with straw, ventilation being provided by means of small upright bundles inserted in the ridge. After standing some little time in that manner, the clamps are covered over with earth to a depth of six inches. When small quantities of potatoes are to be stored they may be placed in conical piles, three or four feet high and six to eight feet wide at the base.

Hay-making.—There are two varieties of hay, viz. "lea" and "meadow," the former coming off arable land, while the latter is the produce of old-laid meadows.

The farmer should begin to cut the crop when the greatest proportion of the most valuable plants are beginning to bloom. If left longer, much nourishment is transferred from the stem and leaves to the seeds, which are readily knocked out in turning the hay. The stems also turn woody. Lea hay is cut before meadow, as it contains a larger proportion of clover, the dried matured leaves of which are liable to be broken off and lost. Cutting is usually commenced in June, and finished in July or August. Supposing the crop to be cut in the morning, it would perhaps be turned with the fork or rake in the afternoon, or left till next day. In the morning of the second day, as soon as the dew is off the ground, the rows or swathes are spread out with the fork, allowed to dry for some time, and may be tedded in the afternoon. In the evening it is raked up into rows and then into cocks. Next morning these cocks are shaken out, and, after lying some time, the hay is tedded. In the afternoon it is raked up into double windrows, and then into single windrows, by uniting couples. In fine weather the hay is then cocked and carted home.

The above process is suitable for meadow hay; for lea hay it is much simpler. The grass cut one day is turned the next; on the third day it is collected with the horse-rake and cocked. It remains in cock three or four days, the length of time depending upon the weather.

In rainy weather, only a little should be broken out at once, so that it may be easily cocked again. Rain falling on the crop when lying out, washes off the waxy bloom protecting the epidermis, and carries away some soluble materials. Alcoholic fermentation may set in, and, among other substances, coumarin (an organic principle giving a pleasant smell to hay) may be lost.

When hay is stored while damp, it tends to ferment. About

15 lbs. of salt sprinkled over every ton of material will check the fermentation, and a little fenugreek improves the flavour.

Hops.—Picking commences as soon as the crop is ripe, which will usually be about the end of August. The work requires a large number of hands, and the operations are performed thus: The bines are cut a couple of feet from the ground, and then the poles, with the bines attached, are pulled out with "dogs" (wooden levers having iron teeth). The poles are taken to the pickers, who pick off the hops, putting them into bins or baskets. The poles are cleared and then stored away. Usually one man is engaged in raising the poles for about eight pickers. The hops are placed in large bins or baskets, holding from ten to twenty bushels. The price for picking varies from $1\frac{1}{4}$*d.* to 3*d.* per bushel. As soon as possible after picking, the hops are dried in kilns. This will reduce their weight to a quarter of what it formerly was. They are then packed in pockets, or sacks $7\frac{1}{2}$ feet long by 3 feet wide, which hold about 1 cwt. 2 qrs. of hops.

The produce varies greatly. The common yield is about seven hundredweights, but it may rise to twenty-five hundredweights per acre. Weight per bushel, thirty-six pounds.

Flax, when grown for fibre, should be pulled by hand before the bolls (seed-vessels) ripen; but commonly it is left later. The crop is pulled in handfuls, and then rippled. Rippling consists of drawing the flax through the teeth of an iron frame; the bolls are pulled off, and are spread out in lofts to dry. Either the same day or the day after, the straw is steeped. It often is spread out for a short time before this to dry. The steeping is performed in ponds of pure water, the object being to decompose the mucilaginous matter about the fibres. When this has been accomplished, the material is dried by spreading it evenly over a grass field, where it remains about four days. It is then rolled up, to break the dried stems, and then "scutched," which removes the rotten, woody, and mucilaginous matter from the fibres. The fibre is made into linen, and the bolls, after drying and turning several times, are crushed. Linseed oil is obtained, and the remainder is pressed into linseed cake.

Produce of straw per acre, two tons, giving about six hundredweights of fibre. Produce of seed, sixteen to twenty bushels.

Hemp is pulled by hand, dried, stacked for a time, and then steeped similarly to flax. The produce of straw and fibre is the same as that of flax; sixteen bushels of seed per acre are obtained. The seed weighs forty pounds per bushel.

Teazles blossom in July, and harvesting is commenced as soon as the bloom is off the heads. The average produce is five to ten "packs" per acre, each pack containing about 20,000 heads.

CHAPTER III.

MANURES—APPLICATION AND MANAGEMENT.

Farmyard Manure.

Of all the manures that the farmer applies to his land this is the one on which he places most reliance, and which occupies his attention to the greatest extent. Artificial manures he looks upon as only subsidiary means for keeping up the fertility of the soil; and though they are often largely used, yet farmyard dung is employed to an extent which completely puts them into the shade.

Farmyard manure is divisible into the three parts:—

1. The liquid portion. This consists of the urine of the stock, together with rain-water, often containing a considerable proportion of the soluble matters of the dung. The liquid manure is the most rapid in its action, and the immediate effects of an application of dung to the land are chiefly due to this constituent.

2. The finely-divided portion, which is the dung proper, and consists principally of the undigested portions of the food. Some of this becomes available as plant-food a little after the previous matters.

3. The litter, or coarser part. This is the most durable, and only becomes slowly available, requiring fermentation and decomposition before it is in a fit state for use by crops.

The quality of farmyard manure varies very much indeed. Among the conditions which affect it, the following may be taken as the chief.

1. **The Species of Animal producing it.**—The excreta from each species of live stock has its own peculiar properties.

Excreta of the Horse.—The dung of the horse is of a very dry nature. It rapidly ferments, and is altogether of a hot character and liable to a kind of dry-rot, or "fire-fang." It ranks next to

that of the pig in richness. The urine also takes second place, but contains only very small traces of phosphoric acid. The manure is the least variable in composition of any.

Excreta of the Ox.—The dung is of a cold, watery nature, quite the reverse of that of the preceding animal. It contains only small proportions of fertilizing matters. The urine takes the third place as regards value. It has a large percentage of alkalies, but only traces of phosphoric acid, and a rather small amount of nitrogen.

Excreta of the Pig.—The dung is of a cold character, but is of rich composition. It contains a much larger proportion of phosphoric acid and alkalies than other dung, and the nitrogen is also in excess. The urine is very poor, being especially low in alkalies, though phosphoric acid is abundant.

Excreta of the Sheep.—This rarely finds its way to the dung-heap, being left on the land on which the flock is folded. Hence it is returned to the soil with the minimum amount of loss. The dung is of rather low percentage composition, when only the dry matter is reckoned, but as it is much more solid than that of other farm stock, it is about the most valuable. The urine is very rich.

COMPOSITION OF DUNG AND URINE.

	HORSE.		OX.		PIG.		SHEEP.	
	Dung.	Urine.	Dung.	Urine.	Dung.	Urine.	Dung.	Urine.
Water	750	900	860	915	760	976	640	950
Solids * ..	250	100	140	85	240	24	360	50
	1000	1000	1000	1000	1000	1000	1000	1000
* Containing—								
Nitrogen ..	6	11	3·6	9	7	3	6	8
Phosphoric pentoxide ..	4	—	3	—	5	1·2	5	—
Potash and soda	35	4	2·2	16	6·5	2	3	8

For the same weight of food it has been calculated that the ox produces more than twice, and the sheep nearly twice, the amount of dung given by the pig.

2. **Age and Condition of the Animal producing it.**—The quality is greatly influenced by this, because, should the beast be requiring large supplies of any one constituent, that constituent will be wanting to a great extent in the excreta. Young animals require an abundance of salts, especially phosphates. Cows in

calf or milk have similar wants. Growing store stock usually give poor manure, and the reverse may be said with regard to mature fattening animals, approaching ripeness. With the latter class an excess of food is needed proportionately to the increase, and that food is usually of the best quality. Working animals give poorer manure than those at rest, owing to the albuminoids being more required.

3. **The Food.**—This is one of the most important factors. The carbon, hydrogen, and oxygen of the food have no manurial value, but the nitrogenous matters and mineral salts are of the greatest use. Such carbonaceous foods, as treacle, sugar, etc., have no manurial value, while, on the other hand, manure from oilcakes and leguminous seeds is of very superior quality. Warington says that if the food be nitrogenous and easily digested, the nitrogen in the urine will greatly preponderate; if, on the other hand, the food is one imperfectly digested, the nitrogen in the solid excrement may form the larger quantity. When poor hay is the diet, the nitrogen in the solid excrement will exceed that in the urine; when cake, corn, and roots are largely used, there is an excess in the liquid portion. We thus see that according to the food so the manner of excretion of various bodies is affected. Lime, magnesia, and phosphoric acid are in greatest abundance in the solid excreta, but the urine contains most of the potash.

One of the best means the farmer has of keeping up the fertility of his land is the feeding of cakes and other concentrated foods to his stock. Both the animals and the dung-heap benefit by the plan. Such foods as straw and roots give very poor manure, and the dung from young growing stock, feeding chiefly on straw in open yards, is decidedly the worst that can be got.

Experiments have been conducted by Sir J. B. Lawes and Sir J. H. Gilbert, at Rothamsted, to find what are the relative values of the manure obtained from different kinds of foods. A table showing the results will be found in the chapter on "Foods" in the "Elementary Textbook," but the amounts there given need to be discounted rather heavily for the waste which always goes on.

4. **The Accommodation of the Animal.**—Stock are housed either in (1) byres or stalls, (2) boxes, (3) yards. In the first plan, pursued with regard to working horses and cows usually, the animals are tied up, and the dung consequently collects at the entrance to the stall. It does not get thoroughly mixed with the litter, and therefore, on removal, which should take place every day, it should be spread out in a yard where it may be thoroughly trampled down by means of young stock.

In boxes the animals have more freedom, consequently the

dung and litter are more thoroughly mixed together. Boxes are often occupied by fattening stock, and the rich food they receive causes an improved quality of dung, which is allowed to accumulate in the box for a considerable time.

The yards are either open or covered. In the latter case they greatly resemble boxes, and the manure from them is of similar character. Open yards allow the rain to wash away the soluble parts of the dung, and, as more straw is needed to keep the animals comfortable, the manure is of low quality.

To test the relative value of dung from covered and uncovered yards, Lord Kinnaird conducted some experiments. The cattle were provided for in a similar manner in every way. The following were the results:—

POTATOES GROWN WITH UNCOVERED MANURE.

	Tons.	cwts.	lbs.
Plot 1 (1 acre) produced	7	6	8
Plot 2 (1 acre) produced	7	18	99

POTATOES GROWN WITH COVERED MANURE.

	Tons.	cwts.	lbs.
Plot 1 (1 acre) produced	11	17	56
Plot 2 (1 acre) produced	11	12	26

Next year, wheat was tried on one-acre plots.

WHEAT GROWN WITH UNCOVERED MANURE.

	Produce in Grain. Bushels.	Produce in Grain. lbs.	Weight per Bushel. Lbs.	Produce in straw. Stones. lbs.
Plot 1	41	19	61½	152 of 22
Plot 2	42	38	61½	160 of 22

WHEAT GROWN WITH COVERED MANURE.

	Produce in Grain. Bushels.	Produce in Grain. lbs.	Weight per Bushel. Lbs.	Produce in straw. Stones. lbs.
Plot 1	53	5	61	220 of 22
Plot 2	53	47	61	210 of 22

The superiority of the covered manure speaks for itself.

5. **The Litter.**—Besides adding to the comfort of the animals, litter has several other properties. It helps to absorb and retain the urine, increases the bulk of the manure, and adds to it various fertilizing ingredients. It is to the litter that the mechanical effects of farmyard manure are chiefly due.

Straw is the litter most commonly used; that from wheat and barley being also more in use than that from oats. Wheat straw contains about 0·48 per cent. of nitrogen (equal to 10¾ lbs. per ton); barley straw contains 0·57 per cent. nitrogen (equal to 12¾ lbs. per ton); oat straw contains 0·72 per cent. nitrogen (equal to a little over 16 lbs. per ton). The ash of the first amounts to about 119 lbs. per ton, of the second 109¾ lbs., and of the third 114 lbs. per ton. Barley straw makes the worst litter.

Peat is very useful as litter when it can be easily obtained. It has a much greater absorptive and retentive power than straw, and the composition is somewhat higher. It contains about 1½ per cent. of nitrogen. Peat also acts as a disinfectant.

Brackens are sometimes used for litter, though not to any great extent. They contain a considerable proportion of fertilizing matters, but are not very absorptive.

Leaves are employed to a small extent. They contain about 0·75 per cent. of nitrogen, but very little phosphoric acid, and about 0·3 per cent. of potash. They are not very well adapted for this purpose.

The amount of litter supplied will depend greatly on circumstances. To make the animals thoroughly comfortable, would, no doubt, take more litter than could be spared. In open yards the maximum amount would be required, and about 48 lbs. per head will be needed daily. In byres the least quantities of litter can be used, as only the entrance to the stall is liable to become dirty. Hence, in a season in which there is a scarcity of or great demand for straw, this method of housing finds favour. About 24 lbs. daily will be needed for each beast in covered yards. Should enough litter not be used, then there is a liability to loss from the escape of matters in solution. Too much litter causes unnecessary expense, and, though increasing the amount of manure, lowers the percentage composition. With yards, the litter is usually allowed to become a little wet and dirty before another addition is made.

6. General Management.—It should always be endeavoured to mix the dung of the various animals as thoroughly as possible. If this be done, the manure will be more uniform, and safer fermentation will result. If the dung and litter are not properly mixed, they may be spread out for a short time in yards in which young stock or pigs are allowed to run. After this the manure is disposed of in either of the following ways:—(1) by carting it direct to the land and ploughing it in, or (2) by making it up into a proper heap. In the first plan the manure is drawn from the boxes in autumn, while in the "green" (or fresh) state. It is distributed over the land in small heaps; these are then spread and ploughed in with a shallow furrow. The method is only applicable to heavy retentive soils. Light gravelly land would allow the soluble matters to be too readily washed out. The advantages are that, when properly done, there is less loss of plant-food, and the texture of heavy soils is considerably improved.

The second plan is most commonly pursued, and may be subdivided into two methods, according as the heap is made

under cover or not. In the former case the manure is formed up into a rectangular heap, upon a bottom which has been previously covered by some vegetable refuse (potato haulms, peat, etc.), to absorb the liquid parts. The excess of urine is collected in large tanks, and, when the mass becomes too dry, a quantity is poured over it. When made in the open air, a suitable bottom is first selected. This should consist of good hard clay, covered with five or six inches of vegetable matters, as before. Under a cover, a concrete bottom is perhaps most suitable. The heap is first made with long sloping ends, so that the carts can drive over it. The ends are then cut off with a dung-knife and thrown up on the heap, so as to make it somewhat ridge-backed. Earth to a depth of about six inches is then spread over the mass, to protect it from the rain. The heap is made in the corner of some field or other vacant place, and the carting from the farmyard goes on during the frosty days of winter, when no injury can be done to the land by the treading. The heaps are sometimes turned in spring, about a month before being required for use. The labourers begin at one end and cast the dung behind them, thus working in a trench between the two heaps. After this, the mass rapidly decomposes.

Cost of Production.—According to some agricultural writers, farmyard manure is an expensive substance. This view has been arrived at by charging hay, roots, and other food at their full market value, subtracting the value of the beef or mutton produced, and then charging the dung with the balance. This, however, is not the proper way in which to view the matter. If the farmer has to turn his crops into beef or mutton, then dung must necessarily be produced. If the fattening animal makes a profit, then the dung is obtained free of charge. But, besides fatting beasts, there are growing and working stocks, and animals in calf or milk. With these, the cost of production would often be difficult to work out. In the farmer's view, however, the dung is a waste product, got for nothing, and therefore the cheapest applicable manure. The litter used is returned to the land, and need not affect the consideration.

Now as to the amount of manure which would be produced yearly. A ton of uncovered yard manure will contain half its weight of water, three-tenths excreta, and two-tenths litter. Say we have twenty head of cattle in open yards for six months (during winter), we would get—

	Tons.
Animal excrements (liquid and solid)	120
Litter (48 lbs. per head daily) = 3·9 or nearly 4 tons each	80
20 animals produce	200

This equals ten tons per head. In covered yards, only half the allowance of straw will be made, and about eight tons of manure will be produced. During the summer months the animals will be out on the pastures, and not contributing to the dung-heap. A bullock, in a box, produces from fourteen to twenty-one tons of manure yearly. A horse makes about twelve tons per year. From experiments by Boussingault, the daily excrements of the cow amount to 73·23 lbs., of the horse 28·11 lbs., of the pig 8·32 lbs., and of the sheep 3·78 lbs. Taking the amount of litter needed by each pig per day as 6 lbs., the amount of manure per year would be 2·3 tons, or from 2 to 2½ tons.

It is an unfortunate fact that dung cannot be produced in sufficient quantities to satisfy the wants of all the crops. It is often stated that a farm should manure itself once in four years at the rate of about sixteen tons per acre. Professor Wrightson says there is scarcely more dung produced than would thoroughly manure one-half the total fallow breadth, but this is going to an extreme. One acre of straw is reckoned to produce about four times its weight of fresh manure, or two and three-quarters times its weight of well-rotted dung.

Application of Farmyard Manure.—Seeing the limited amount available, it is a point of interest as to which crop it can be most profitably applied. The general rule is to give it as a dressing to the roots, with a little to the seeds, provided there be enough. Those parts of the root crop some distance away from the farm steading will be best manured by folding sheep on them. The cost of carting the roots home, and then returning the dung to the land, is avoided. The crop nearer home will receive a full dressing, and by this plan a small amount will be left over for the seeds. This latter portion, applied in winter or early spring, nearly always produces a good crop, and an abundance of clover will result in an excellent wheat crop.

Dung is applied at almost any time during the year. In January and February, to young seeds; in March to potatoes and meadows; in April to mangels and kohl-rabi; in May and June to turnips and swedes; in July to bare fallows; in July and August for wheat; in September to vetches, rye, and cabbages, etc.; in October, November, and December to grass and seeds for next year's crop. Among the fallow crops, swedes, mangels, and cabbages get twenty to thirty tons per acre; white and yellow turnips and potatoes, fifteen to twenty tons. Beans, peas, vetches, rye, and seeds receive twelve to fifteen tons per acre; and wheat fifteen to twenty tons. With these amounts no artificials are given.

From what has been said before, fresh dung produces its

greatest effects on heavy land, while light soils require it to be well rotted. Hilly fields are more suitable for the application of artificial manures.

The cost of applying farmyard manure to land is usually the only expense connected with its use. The following shows the method of finding this amount with regard to turnips :—

	£	s.	d.
4 horses and carts carrying dung, at 3*s*.	0	12	0
2 boys driving, at 1*s*. 6*d*.	0	3	0
3 men filling dung, at 2*s*. 6*d*.	0	7	6
6 women spreading manure at 1*s*. 3*d*.	0	7	6
Cost per day (for four acres)	£1	10	0
Cost per acre	£0	7	6

Guano is formed of the excrement of fish-eating birds, together with their remains. It is found in dry, rainless districts, chiefly along the coast, and on the islands near the coast of Peru, and other places there, between the thirteenth and twenty-first latitudes. To the natives of those districts the use of guano has long been known. Its name is derived from the Peruvian word "huano," meaning dung or manure. It was first imported into this country in 1839, and the amounts brought over rapidly increased till about 1870, since which they have gradually declined. Guano is now also brought from many places on the African coast.

Application of Guano.—The soils to which this valuable manure can be best given are those of a clayey character. On light lands there has not been so much success, chiefly for the reason that they have little retentive power for ammonia. In such cases it would be well to apply it in a compost. Peruvian guano is also not a suitable manure for calcareous soils. It appears that there is some loss from the volatility of the ammonia. These remarks apply chiefly to the nitrogenous guanos. The other form may be looked upon as a phosphatic manure.

Peruvian guano is an excellent dressing for the cereal crops. It should be given in spring, at the rate of two to four hundredweights per acre. Both kinds give good results with turnips and swedes in the north of England and Scotland. The damp climate allows of its more rapid and extensive action, and it has often been noticed that in drier districts the benefit received is very little. Four or five hundredweights per acre is an ample dressing.

On no account should guano be allowed to come in direct contact with the seed, as its caustic nature is apt to destroy the vitality. For this reason guano should not be drilled in with the seed. In the north it is broadcasted over the rows a short time after sowing the turnips, and with the wheat it may be given as a top-dressing. Applied to roots, it has usually been found to

diminish the number of plants per acre, but to increase the individual size, and, generally, the crop as well.

Human Egesta.—The objections to the extensive use of this manure are the offensive smell, and difficulty in carriage. To remedy the former, it is mixed with earth or some deodorant, and is then known as night-soil.

Night-soil.—Various substances have been used for mixing with the excreta, among the most common of which is dry earth. The proper rate of supply varies from five to ten pounds per individual, to be applied daily. The manurial value is not very high, and this, coupled with the bulk and consequent expense of carriage, has prevented its extensive use. In China, Japan, and Belgium, night-soil is still much employed. Instead of earth (of which well-dried loam is best), powdered peat may be used. It is more absorbent, and, on the whole, the better preservative.

Poudrette is, or rather was, made from night-soil, etc. The process seems to have been first carried out near Paris. The excreta, solid and liquid, were placed in large tanks; and, after most of the solid matters had settled to the bottom, the supernatant fluid was drawn off into a lower series. After standing some time here, the liquid was passed through a bed of sand, and then run into the Seine. The solid matters obtained were frequently raked out of the tanks, and spread in fields to dry. Usually a deodorant, as gypsum or some other calcareous substance, was mixed with it. The use of the resulting compound is limited, but it is still made at several places on the Continent, and also in America.

Liquid Manure.—The mixed urine and drainings from the dung-heap should be allowed to stand a few weeks before application. A tank of rectangular form is most convenient for this work. It is built of masonry or concrete; the bottom should not be more than four feet below the drain-pipes. A tank twelve feet square and of this depth is sufficient for a steading of three hundred acres. The place is covered in with an arched roof.

Before application to the land, the urine will generally need dilution with sometimes as much as twice its bulk of water. Where a large amount of rain flows into the tank, this may be dispensed with. When applied to the fields fresh and undiluted it is apt to produce burning effects, just as guano does.

The soils most suitable for this manure are light, open loams. The application is performed by the liquid-manure cart, or by irrigation (see the chapter on this subject). The best results have been obtained with grass crops.

Sheep Manure.—As stated before, owing to the flocks being nearly always feeding upon the land, they contribute very little

to the dung-heap. Their manure receives the least amount of loss, and hence one of the chief reasons why folding sheep on turnips gives such excellent results. The manure is evenly distributed over the fields, and well trodden in. The labour of carting is saved, and on light land the folding has an excellent consolidating effect.

Seaweed is applied to the land, either in a fresh or well-rotted state. In the latter case it is usually made into a compost with other refuse, and often with marl and shell-sand. The mass is turned once or twice, and rapidly decomposes. There is usually great shrinkage during storage, as a considerable proportion of the water is got rid of, and the ash will then amount to from 18 to 32 per cent.

Seaweed may be ploughed into the land in autumn, at the rate of twenty to thirty tons per acre. Owing to its cellular (and not fibrous) character it rapidly decays. Clay lands are well adapted for this process.

In Ireland and Scotland, seaweed is chiefly applied to potatoes. It is ploughed in fresh, and allowed to decompose before the sets are planted. It has been noticed that potatoes grown in direct contact with the seaweed are more liable to disease than others. In any case they are very watery, and not of such good quality as those grown without the dressing, though a larger crop is obtained.

As this manure contains a fair percentage of potash, it answers well for clover, when applied as compost.

Composts consist of collections of organic rubbish mixed with lime in the proportion of about five to one. Weeds, potato haulms, leaves of root crops, peat, hedge trimmings, ditch and pond dredgings, road scrapings, fallen animals, etc., are made use of. The composition is extremely variable, according to its source. There can be no doubt that such collections of waste materials are good means of preserving the fertility of the land. They can be made in any spare place and at any convenient time. They should be allowed to decompose in the heap for a few months, after which much of the organic matter will readily give up its plant-food. It will be noticed that composts are very similar to farmyard manure, and the notes about the management and application of that material are here equally applicable.

The disadvantages of composts are: (1) the expense of carting, owing to the bulk; (2) the low composition; (3) they may contain a great number of weed seeds, and also serve as the home for insect and fungoid pests. If enough lime were used, a large proportion of these foes might be killed, and more especially so with gas-lime; but those still remaining may prove a nuisance.

Refuse Cakes.—Owing to their high price and value as food, most cakes cannot be used for manure, unless in a mouldy or damaged condition. Rape, mustard, and castor cakes are most frequently used for this purpose. The two last are of no value as foods; indeed, they may even be dangerous to stock. Powdered rape cake is often used as manure—in experiments chiefly, and not so often in the ordinary way. It has been found to answer well for spring wheat and potatoes; when given to autumn wheat, rape-nuts give the best results. Sir J. B. Lawes speaks highly of it as a manure for grain crops, but it is doubtful whether it will always pay for application. The best effects are obtained on heavy soils, rather than on light lands. From 5 to 6 cwts. per acre have been recommended as a top-dressing for wheat on heavy soils. There is another use to which rape cake may be put. Miss Ormerod says that it should be broadcasted over a gramineous crop when attacked by wire-worm. It stimulates the plants, and is also distasteful to the pest.

The other cakes are seldom applied to the land. It must be remembered that they contain large percentages of oil, and do not decompose readily.

Artificial Manures.

Nitrate of Soda.—This has a quicker action than other ordinary nitrogenous manures. This is owing to it being in a form at once available for plants, and, as it is very soluble, it is of great use in dry seasons. It is said that nitrate of soda has a tendency to sink in the soil, thereby drawing after it the roots of plants, which may thus obtain moisture from the deeper layers of the soil.

Nitrate of soda is sometimes spoken of as a mere stimulant, or "whip." The term is one which should never be used, as it does not express the proper action of the manure. It was formerly thought that the use of nitrate of soda soon exhausted the land; but this is generally incorrect. The idea arose from there being only one important plant-food constituent (nitrogen) in the manure, and, as crops would require others proportionately, these remaining materials would be unduly called upon. There seems, however, to be little to fear on this account, though it certainly would not be wise to annually apply nitrate of soda to the land without other manures. The extra yield in straw or roots from its use produces a larger dung-heap. This means a greater return of fertilizing matters to the soil, not only from the crop, but also from purchased concentrated foods which have been profitably used with the straw. It is thus that the one-year effect of this artificial is seen to be of permanent benefit.

When used moderately and with other manures, nitrate of soda has a very good effect. It has a tendency to cause a luxuriance of stem and leafage; hence it is of much use to forage crops. With corn and roots this abundance of foliage is checked by the application of salt. It should also be noted in connection with the effect upon cereals, that an increase of grain is also obtained. The ear is fed by the straw, therefore the better developed the latter part is, the greater will be the produce of seed. Nitrate of soda causes an increased percentage of albuminoids and soluble carbohydrates in the crop. It also causes the plants to grow quicker and mature earlier. Sodium nitrate should never be used in quantities above 4 cwts. per acre.

The usual dressing of nitrate of soda is $\frac{1}{2}$ to $1\frac{1}{2}$ cwts. per acre, generally broadcasted over the growing crop. It is given to nearly all crops, but should never be applied to the land before the seed is sown. It suits clay soils best.

If the farmer supplies plenty of other manure with his nitrate, he need be in no fear of exhausting his land. On account of its quick action it is the best manure to apply late in the season. It is of great use in hurrying turnips past an attack of the "fly."

Sulphate of Ammonia.—$1\frac{1}{2}$ cwts. per acre are often used as a top-dressing for corn, grass, or root crops. This manure is said to improve the malting qualities of barley, and to increase the yield of grain of all cereals without detriment to the straw.

Gas-liquor.—By itself, gas-liquor would destroy much vegetation, especially in dry weather. When diluted with four to six times its bulk of water, it may be applied with advantage to pastures, especially on clay soils. Peat and sawdust may be used to absorb gas-liquor, and then applied to the land with bone meal, or made into a compost. Gas-liquor is said to destroy moss on pasture, and to kill slugs.

Dried Blood is a fairly good manure, and is often applied with great advantage to wheat, grass, and turnips. The amount applied per acre is 20 to 30 bushels for wheat and grass land, and 40 to 50 bushels for turnips. Before application, the dried blood is broken up to a powder. It is most beneficial on light lands.

Soot may be applied at the rate of 30 to 60 bushels per acre, mixed with a few bushels of common salt or lime. It is useful in destroying slugs.

Superphosphate of Lime is given to nearly all crops, in quantities of 1 or 2 to 8 cwts. per acre. Root crops, especially turnips and swedes, are greatly benefited by the application.

Dissolved Bones.—From 4 to 6 cwts. are applied per acre to roots and grass land chiefly.

Bone-ash Superphosphate should always be in a fine powdery condition. Three or four hundredweights per acre may be given to root crops, especially those on cold clays or damp marly soils. This manure is supposed to promote the early maturity of the crop.

Bones are said to be, as a rule, better adapted for light lands than for heavy soils, owing to their partial solubility. They are top-dressed on pastures, at the rate of 9 to 14 cwts. per acre, and by some authorities are said to have an effect on the land for twenty years afterwards. Bones have good effects on peaty soils, but should not be used on land containing an excess of lime.

Basic Slag is derived as a by-product in the manufacture of steel by the Bessemer process. The molten iron is mixed with about one-fifth of its weight of lime. The Bessemer converter also has a lining of lime. The various impurities combine with the lime, and the product forms the basic slag. Before being used, the slag should be ground up to an impalpable powder, as its degree of solubility depends largely upon the fineness of its particles. Eighty-five per cent. of it should be able to pass through a screen with 10,000 holes per square inch.

Basic cinder succeeds well on peaty soils and on heavy lands. On light soils it is said to have not such a good effect as superphosphates. Five or ten hundredweights per acre may be given to pastures, on which it succeeds better than on arable land. When applied to roots, it should be broadcasted over the land a few weeks before sowing the seed, in order that it may get dissolved.

Kainit acts best on dry light soils, and should be given in conjunction with nitrogenous and phosphatic materials, never alone. Three hundredweights per acre is a sufficient application; too much of a potassic dressing is said to have an injurious effect on vegetation. It should be sown early. Many authorities recommend that it be given in autumn, especially on limestone soils. It appears that sulphuric acid is liberated, and this combines with the lime. If applied with the seed, according to these ideas, the crop might be injured by the reaction.

Sulphate of potash is an excellent manure for leguminous crops, though rather expensive. $1\frac{1}{2}$ cwts. may be given per acre.

Polyhallite, though not often used, is said to give better results with potatoes than kainit.

Muriate of Potash, being very concentrated, needs only to be applied at the rate of $\frac{1}{2}$ to 1 cwt. per acre. Jamieson and Munro have shown in some cases, as when a large excess is added, that potassium chloride may act as a plant-poison.

Wood ashes are, in Canada, applied at the rate of 40 bushels per acre to potatoes. On pastures they tend to destroy moss.

Wood-ashes have a good effect on young corn, and, when mixed with guano or bone-meal, they are of great use for turnips.

Carbonate of Lime is of use to nearly all plants, but especially to peas, beans, sainfoin, lucerne, and pasture grasses and clovers. Barley is also much benefited by it. The carbonate is of greater use on light soils than on heavy. Lime is not usually applied to land every year, but once every rotation or alternate rotation, or even once in nineteen years. The amount given to the land equals about 8 or 10 bushels per acre per year, put on the lea or fallow. It is best to apply a fair amount of quicklime to the land first, and then to give small dressings of carbonate of lime as occasion requires. Lime has a tendency to sink in the soil, hence large dressings are not of much value.

Gas-lime must be applied in autumn. It is not a very useful manure, and can be bought at about *2s.* per ton.

Common Salt may be given to mangels at the rate of 4 or 5 cwts. per acre. It may be given either as a top-dressing, or mixed with farmyard manure or compost. Near the sea-coast the land generally contains enough salt, brought by the sea-winds. When in too large amounts, sodium chloride causes barrenness; but some plants may have a decidedly saline taste and yet flourish. One per cent. of salt in the soil will prevent many seeds from germinating healthily.

Sodium Carbonate has proved beneficial to clover and grass-lands in the form of a top-dressing. It may be mixed with an equal amount of guano or bone-dust; the compound, at the rate of 3 cwts. per acre, is useful for potatoes and turnips.

Sodium Sulphate is said to be good for cereals and leguminous crops when given in conjunction with other fertilizers. It succeeds best on light land, and is used at the rate of $1\frac{1}{2}$ to 2 cwts. per acre. It is employed only in experiments, like most of the sodium, iron, and magnesium salts.

General Application of Manures.

It has been found that the rule "Little and often" pays best with manures. With heavy dressings, much more of the ingredients will be washed out of the soil. The same, applied frequently in less amounts, just provides for the wants of the plants for the time being, and hence the crop gets the maximum benefit from fractional dressings. At Rothamsted, it was found that with heavy and light dressings of nitrate of soda to a cereal crop, 47 and 60 per cent. respectively of the nitrogen was recovered in the yield.

Manures are applied before, with, or after the seed. Insoluble

compounds, as farmyard manure and most general manures, bones, etc., may be applied in autumn. Others, as basic slag, which are not so insoluble, may be given a few weeks before seeding. Superphosphate and the majority of artificials are put in with the seed, being either drilled with it or broadcasted over the land about the same day. Only very soluble manures must be used for the top-dressing. Nitrate of soda is especially adapted for this purpose. They can be well applied by the Strawsonizer (see the chapter on "Agricultural Engineering"). The water-drill is also useful.

Manuring depends somewhat on the season. When wet, ammonium sulphate is to be used in preference to nitrate of soda, being less easily washed out by the rain.

The manures for the various crops will be found among the other details of their cultivation.

CHAPTER IV.

DRAINAGE.

Drainage is one of the first operations usually carried out in improving land. Unless a soil be well drained it is of little use applying manures, folding stock upon it, or trying to do anything which would otherwise be of great benefit. The good effect is completely neutralized by the water-logged soil. Should the land, however, be well drained naturally, as, for instance, on some light porous soils with considerable slope, artificial drainage need not be carried out.

Drainage allows the soil to be employed to the greatest advantage, and in these days of keen agricultural competition, when farmers have to be content with small profits, it helps them greatly to have a soil on which it will pay to go in for "high-farming."

The Theory of Drainage is not so much to get water out of the land, as to get it in,—to get rid of stagnant water so that a fresh supply can take its place. The object is to keep a soil moist rather than to get it very dry or very wet. On a drained soil the rain which falls soon passes down into the drains and thence escapes. On an undrained field the water gradually accumulates, not being able to escape, and thus prevents any falling rain getting away. The soil consequently becomes water-logged, and vegetation, to a certain extent, is injured.

Causes of excessive wetness.—Rain is the primary cause of wetness in land, and when it proceeds entirely and directly from it, the land is said to be "surface-wet." Many clay soils are more or less injured in this way. The texture of the land is so fine that the water is scarcely able to percolate through it, and consequently collects in a pool on the surface. The taking off of such water is called "surface drainage;" when it works its way into the soil, and is then carried away by artificial means, the process is termed "under drainage."

On light free soils the rain can easily find its way into the deeper strata, and in this manner wetness may be produced under the following conditions. The water on passing down may meet with some impervious strata, as a bed of limestone or clay, and, as a consequence, would begin to rise and swamp the land.

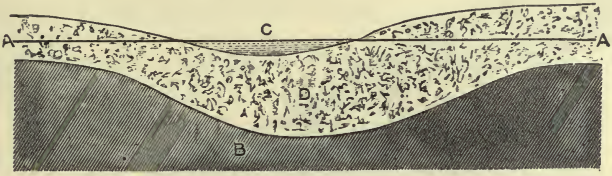


FIG. 39.

The figure illustrates the above statement: D is a free soil resting upon an impervious bed, B. The water rises in it until it reaches AA, at which layer it will spread over the surface of the land, forming a pond, C.

Another case in which a soil may be wet owing to impervious beds, is seen in the next figure. The light soil, BB, rests between two strata of clay, A and CC, but is exposed toward S, where it

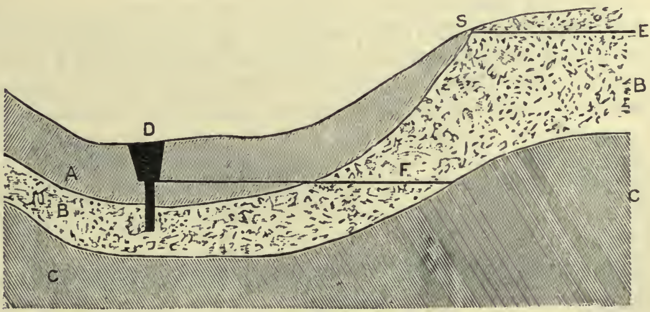


FIG. 40.

forms the summit of a hill. Rain falling there will quickly pass down between the two impervious strata, and will then rise again until it reaches the level E, at the end of the stratum A. It will then issue forth as a spring from S, and, by flowing over the land A, will produce a swampy piece of ground. Should a drain be dug at D, on Elkington's principles, the level of the water will be reduced to F. When water rises from below, as in the above case, it is called "diffluent."

In the next case, the water-bearing strata B comes to the surface at D, and thus the land is wet as before. In draining this land, a drain at E would be too high, while one at G is too low.

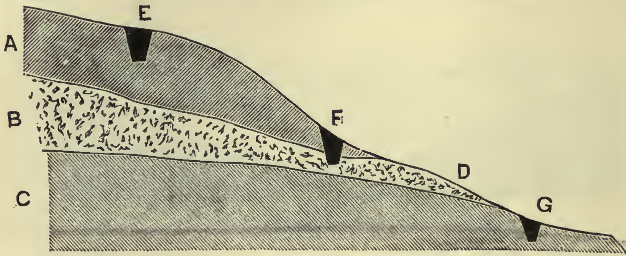


FIG. 41.

The one at F, however, would penetrate the stratum B, and carry off the water.

It will be seen that soils may be divided into two classes as regards drainage—

(1) **Free soils**, as loams, sands, peats, and vegetable loams.

(2) **Impervious soils**, as clays and beds of rock.

If the first class require drainage, it is because they are wet from position (through water passing into them from other levels), or there may be some retentive substratum below them at a greater or lesser depth. They do not offer much opposition to the passage of water through them, and hence they often convey water for considerable distances along their course if there be no impervious bed in the way. Free soils are said to be wet from bottom to top; that is, the water descends until it meets some hard stratum, which stops its course. With more rain, it rises and begins to wet the soil.

The second class of soils offer considerable resistance to the passage of water. The water collects on the surface and passes gradually downwards; hence such soils are said to be wet from top to bottom.

We have now seen how water gets into the soil, and also that its primary source is the rain. The rainfall of different parts of England varies very much, but, as a rule, it is greater in the west than in the east. The reason for this is easily seen. The eastern winds blow across the dry plains of Central Europe, and consequently are not able to take up much moisture. The winds from the west, however, pass over the large expanse of water, and hence are very moist, and, through blowing over the Gulf Stream,

are also of a warm nature. The eastern rainfall averages about twenty-five inches, the western thirty-six inches.

Height of Water in the Soil.—Water, even in undrained soils, does not always stand at the surface. The limit at which water stands in the soil is called the water-table. Above this the soil is wet only from capillarity, below this the soil is constantly water-logged, and is called the "reservoir," or "area of supersaturation."

In A the soil is completely water-logged. In the section B, the land is wet at the surface by capillarity. In C, the water-table,

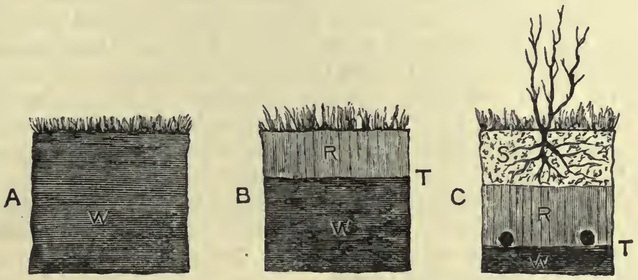


FIG. 42.

T, has been much lowered by drains, and there is a dry "blanket," S, at the surface which allows the roots of plants to spread through it. It should be remembered that the roots will not live in the water-logged part, and hence decay when they reach the water-table.

Advantages of Moving over Stagnant Water in the Soil.—In order that a field may be kept up to a proper state of fertility during cropping, fresh plant-food must be made available in the soil. Although water is more or less a solvent, yet by simply standing in the soil, it does not exert its influence to any extent. It does not move about, and it is greatly to the rapidity of its motion when in the form of streams that its dissolving powers are chiefly due. Again, air finds great difficulty in getting into a water-logged soil, owing to the spaces between the particles being already filled. When the water passes out of a soil after drainage, air must follow or else a vacuum would be formed. The action of air on the soil is well known. It oxidizes various substances, rendering them more or less soluble, and thus of use as plant-food. The soil is also more friable, and thus more easily tilled.

One very important advantage of drained lands is, that rain

can easily pass in, and the value of this will be seen when it is remembered that certain amounts of plant-food are thus obtained. At Rothamsted it has been found that 4·4 lbs. of nitrogen per acre are thus obtained on an average yearly. The amount is made up of 2·4 lbs. nitrogen as ammonia, 1 lb. as nitrates and nitrites, and 1 lb. as organic nitrogen. Near the sea, chlorine is found in fairly large quantities, and even at Rothamsted, in Herts, chlorine equal to $24\frac{1}{2}$ lbs. of common salt per acre per year is obtained, while at Cirencester 45 lbs. are estimated. This amount would be found sufficient, except for a few crops, such as mangels, which originally were maritime plants. Sulphur, equal to $18\frac{1}{2}$ lbs. sulphuric anhydride (SO_3), is also obtained per acre, besides small quantities of other gases. During a thunderstorm, the electricity is said to cause the union of nitrogen and oxygen to form small amounts of nitric anhydride (N_2O_5). The rain, which usually falls then, brings this valuable substance down to the earth, where it would combine with a base to form a nitrate. The various gases, thus contained by the rain, will pass into the drained soil, and there form useful plant-food. On undrained land, the soil is already full of water, and hence little or no rain, with these valuable matters in solution, passes in; the larger part flows off the surface, and is lost.

General Advantages of Drainage.—(1) The temperature of the soil is raised. In a small way this is effected by the rain passing through the soil, especially during thunderstorms, when it is often several degrees higher in temperature than the land. On undrained land much of the heat of summer is employed in evaporating the surplus water, and does not warm the soil to any extent until this is done. But the sun is at a great disadvantage in evaporating the water, for it can only pour its rays down on the surface. Hence convection alone takes place, and this is a very slow process. Should, however, a cold wind blow across the field the land is quickly chilled (by conduction). The top layers of water are reduced in temperature, and sink, while others take their place. By this it will be seen that water-logged soils are easily chilled by cold winds, but not warmed readily by the sun.

(2) Improvement of the mechanical condition of the soil; especially with clays. The air, after oxidation, causes the soil to be much more friable, and thus easily tilled.

(3) The air promotes the more rapid decomposition of organic matter in the soil; the products of this oxidation and decay are better suited as food for plants. During decomposition, various gases, especially carbonic acid gas, are often given off, and these again are of use in forming more or less available plant-food with mineral substances. With imperfect oxidation, as in undrained

land, sour organic acids and other bodies, injurious to vegetation, are formed.

(4) The land is much drier, and hence all plants, except those of an aquatic nature, are able to grow in a more natural state.

(5) Fogs and mists, caused by the accumulation of moisture in the air, are less frequent, and consequently the crops get more light, which is essential to their growth.

(6) The land can be better cultivated, nothing injuring heavy soils so much as to work them when wet. On this account the plants can be sown earlier, and on a better seed-bed.

(7.) Drainage prevents efflorescences on the surface. The efflorescences are caused by the evaporation of aqueous solutions of salts at the surface of the soil. On drained land the descending rain washes them down into the soil again.

Practical Advantages of Drainage.—The advantages previously described have been partly theoretical, but drainage is of great practical use, as every farmer knows. The following are the chief advantages which an agriculturalist would receive after draining his land.

1. An earlier harvest. We have already seen how land is raised in temperature by drainage. It is well known that with a lower mean temperature through summer, the grain takes much longer time to come to maturity. One of the causes of this delay on undrained land is that the plant has to take up its mineral food in very dilute solution, and a considerable amount of heat is used up in evaporating this surplus water. A difference of ten days has often been noticed between the ripening of wheat on drained and undrained land, and this is of great importance in some parts, such as the North of England, where stormy wintry weather begins early.

2. Larger crops. This is accomplished in various ways. (*a*) Plant-food is carried into the soil by the rain, as already seen. (*b*) On account of the air being able to penetrate drained soils, insoluble substances are acted upon by the gases it contains, and to a certain extent rendered soluble. (*c*) The roots of the crops are better developed and are more able to search for their food, owing to their greater strength and numbers; the soil is also more friable and easy to penetrate. (*d*) Injurious substances often exist in undrained soils, and these prevent growth; when the land is drained they are oxidized and rendered harmless. (*e*) Autumn-sown crops are often much injured on undrained land by frosts, owing to the more sodden state of the ground. It has been calculated that 25 per cent. more corn and 70 per cent. more grass have been obtained on draining a poor soil.

3. Better quality of produce. A healthy crop can scarcely be expected to grow upon an unwholesome soil, and it is on undrained land that such diseases as blights, mildews, rusts, and other fungoid pests are most common. The plants are also weakened by the water-logged state of the soil, and hence they easily fall a prey to the attack. Pt. I. chap. iv., E, describes the most common fungoid diseases.

4. A greater variety of crops can be grown. On undrained land, no winter cultivation can be attempted to any extent, and hence it is scarcely possible to get in a catch crop. The land has often to lie idle, and renew itself by a bare fallow. After drainage this may be greatly done away with, and some fallow crop, as turnips, swedes, cabbages, and mangels are grown instead. Barley, clover, and many other crops can be cultivated with greater certainty; and forage crops, as vetches, will now be grown.

5. A large number of the seeds sown will germinate, and thus a thicker braid is obtained. The three essential conditions of successful germination are heat, air, and moisture. The last an undrained soil may give, but heat and air are scarcely obtained in proper amounts.

6. Good natural grasses spring up in the pastures. Before drainage, only the coarser kinds of grass grow, and these over-power any finer varieties that may be springing up. Drainage deprives them of the large amount of water which is essential to their growth, and favours the finer kind. Rushes, sedges, and other aquatic herbage are got rid of.

7. Drained land suffers less from drought, as the plants will have their roots better developed and much deeper than on undrained soils. They can thus obtain water from the lower layers of the soil.

8. There are fewer injurious insects, as these love places with coarse rank herbage. The crane fly ("Daddy Longlegs") is one of the many that will disappear.

9. Tillage is rendered easier and less expensive. Dry land is always easier to work than wet; the moisture causes the particles of soil to hold together more, and thus prevents the onward progress of the plough or other tillage implement. Again, clays must never be worked when wet, or they will form into hard clods on drying. Drainage (1) lessens the time required to till the land, and (2) increases the number of working days. In consequence of this, fewer horses and men will be needed, and there will be no great strain upon the working staff in fine weather.

10. Manures are more effective. Upon undrained lands

manures have little or no effect. They do not allow the manure to get well into the land; it remains about the surface, and the next shower washes more or less of it away. It does not matter much how the manure is applied, whether as artificial dressings, farmyard dung, lime, or as foods fed off to the cattle or sheep on the land.

11. Nitrification is promoted. Before this important operation can take place, heat is needed by the bacteria, and also moisture, but not an excess of water. The temperature of wet lands is, however, generally too low for the operation; and the excess of water, with the absence of oxygen, causes free ammonia instead of nitric acid to form, if the operation does go on. The ammonia in its uncombined state is useless to the plant, and is generally lost.

12. Health of live stock grazing on the land is improved. Foot-rot, attacking sheep, is chiefly caused by damp land growing rank herbage and having a soft turf. The *Distoma hepaticum*, or "liver fluke," can only pass through one necessary part of its existence in a certain snail (*Limnæus truncatulus*), living either in fresh water or in swampy parts caused by fresh water. Among calves, the nematoid worm (*Strongylus filaria*), causing "husk" or "hoose," frequents low, marshy, and undrained land. Red-water and black-quarter, affecting cattle, are chiefly found on cold wet land.

Again, stock thrive much better and lay on flesh much faster on a warm dry soil than on cold wet land. Cattle, after filling themselves, would, in the former case, lay down and chew their cud contentedly; the result would be more milk and flesh. On the second class of soils the cattle may often be seen standing shivering, and losing, rather than gaining, flesh.

13. Should the drainage be on an extensive scale, the health of the rural population is improved. Agues and rheumatisms especially begin to disappear, and the benefit of this will be felt by the farmer in his improved health. The temperature of the district would be raised a few degrees with plenty of drainage.

Signs of Wetness in Soils.—A soil will show unmistakable signs when suffering from wetness, of which the following are the chief:—

(1) Snow lies longer on cold wet soils than on the warmer and drier drained fields.

(2) The newly-turned furrow has a glazed appearance.

(3) Pools of water often collect on the surface.

(4) Cracks appear in the soil during dry weather, owing to the great contraction from a water-logged state to a dry, baked condition.

(5) A curling of corn in the leaf.

(6) A wiry appearance of the grass, which also has a bleached look, and does not attain the bright green colour of healthy grass.

(7) The formation of a mossy substance on the surface of the ground.

(8) A spindling growth in grain crops, with a lightness of colour.

(9) Stunted and blighted straw at harvest.

(10) The appearance of rushes (*Juncus*), sedges (*Carex*), and a certain aquatic flora.

The following grasses indicate wetness, and are often removed by drainage, to the great benefit of the pasture:—

Black bent (*Alopecurus agrestis*), floating foxtail (*A. geniculatus*), marsh bent (*Agrostis vulgaris alba*), tussac grass (*Aira cæspitosa*), quaking grass (*Briza media*), water whorl grass (*Catalrosa aquatica*), purple melic grass (*Molinia cærulea*), reed canary grass (*Phalaris arundinacea*), floating meadow grass (*Poa fluitans*). Sweet floating grass (*Glyceria fluitans*) also often grows on wet land. Among other plants there are sedge or "carnation grass" (*Carex*), rushes (*Juncus*), spotted-leaved orchis (*Orchis maculata*), marsh orchis (*Orchis latifolia*), docks (*Rumex*), marsh thistle (*Carduus palustris*), horse knot (*Centaurea nigra*), silver-weed (*Potentilla anserina*), self-heal (*Prunella vulgaris*), meadow crowfoot (*Ranunculus acris*), marsh cud-weed (*Gnaphalium uliginosum*).

Should these signs be observed, it will be the duty of the farmer to drain the land.

Systems of Drainage.

These are primarily divided into Surface Drainage and Under Drainage.

Surface, or Arterial, Drainage.—Surface drainage undertakes the removal of water from the surface of the land by means of open channels of greater or less depth. It consists chiefly in the improvement of natural watercourses. The channels ordinarily consist of the open furrow left by the plough between the ridges, with another furrow crossing these at the bottom of the field, and thus taking all the surface water away. Small "sheep" drains, fifteen inches deep and eighteen inches wide, are often made on upland pastures for carrying off water.

Arterial drainage is never of great importance on any soils, but is of greatest use on clays and such-like impervious beds as are surface-wet. Where under-drainage is performed,

it is not needed, but on wet clays open ditches are almost a necessity.

One great objection to surface ditches is that they allow valuable ingredients to be washed away and lost. Thus, on an undrained field, should any manure be applied, it is readily washed off the surface by the next shower of rain, without even entering the soil.

Ditches require to be cleaned out yearly, and their edges to be sloped again, as earth often falls into them. With small streams constantly running through arable fields, it is well to have a narrow ridge of grass on the edge, lest earth should be drawn in during cultivation.

Under-drainage.—This is the chief kind, and the only one advisable to use. In it the means of conveying away the water are covered in, and thus the cultivation of the soil is not in any way interfered with. There are several methods of under-drainage, of which the following are the most important:—

Essex System.—In this system a trench, two feet deep, is dug, and then some open material, such as thorns, faggots, straw, or brushwood, is placed at the bottom, and the earth is pressed in upon it. The passages between the materials at the bottom of the drain allows the water plenty of room to run away, and as they soon decay, a fair-sized hollow will be formed. The lines of drains are run parallel to each other in every furrow or alternate furrow.

The object of this system is to take off surface water; it consequently is best on clays. It is not commonly practised now, owing to its not freeing the soil entirely from water.

Elkington's System.—This system is chiefly applicable to clay soils below which lies a water-bearing strata. In such cases as these, a simple trench would scarcely be of any use, as, unless the free soil is near the surface, it will not be penetrated. Hence Elkington dug sinkholes into the water-bearing strata : the water thus found an outlet, and was conveyed away by trenches. In Fig. 40 the land is drained on Elkington's principles. The trench at D by itself does not enter the stratum BB, which is the source of the water. The sinkhole from the bottom of this trench, however, taps this, and speedily reduces the water-table from E to F. In this system it is not necessary that the drains should be parallel, or that they be distributed over the land. It should be endeavoured to cut the drain across the lowest part of the water-bearing strata, and thus get the water away at the point of least resistance. The trenches carrying away the water need not be deeper than 3½ feet.

The next figure represents the drainage on Elkington's system

of a pocket of clay. H represents the bed of clay surrounded by the gravelly water-bearing strata F. It can be drained in two ways: (1) by having a drain in the position C, the pipe from which reaches to the bottom of the "pocket;" (2) by cutting the drains A and B at the sides. The second plan would reduce the

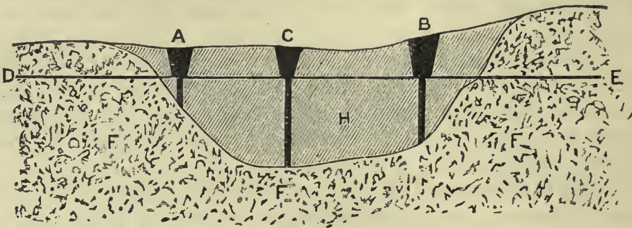


FIG. 43.

water-table quite as much as C would do, and, not having such a thickness of clay to cut through, would scarcely cost as much.

Elkington's system only attempts the removal of spring water, and does not deal with the direct rainfall. It also requires a considerable amount of skill and practice, in order that the drains may be laid with the greatest advantage.

Smith of Deanstone's System.—This is the commonest system of drainage, and is applicable to nearly all soils. It consists of a parallel series of drains, leading into a main drain, which opens into a river or some other convenient place. The main drain runs along the lower part of the field, and receives the water from the submains and laterals. The submains ascend the smaller hollows. Where these are wide enough, there may be two sub-

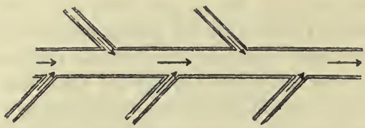


FIG. 44.

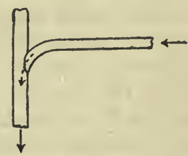


FIG. 45.

mains, one along the base of each of the bordering slopes. The laterals are the smaller drains. Both submain and the lateral should enter into the larger drain at an acute angle of less than 60°, and alternately. By this means there is no stagnation of water at the entrance of a drain, for the incoming water is moving partly in the direction of the main drain, and not going against it.

Consequently there is no deposition of silt, or fine mud. Sometimes, when the laterals are coming down a slope, they approach the submain almost at a right angle. The joining must, however, be effected at an acute angle, and hence use is made of a joining-tile, as shown in Fig. 45.

The Practice of Drainage.

We shall now consider the construction of drains. Enough has been said about Elkington's system, consequently Smith's system only shall occupy our attention.

Direction of Drains.—In order that the water may be rapidly taken away, the main drain should occupy the lower part of the field, and have its outlet at the lowest point. Submains may in many cases be dispensed with, but where the land is very uneven they are necessary. The little valleys through which they run often have collected the water from the ridges for long periods of time, and hence they to a great extent get rid of water from the small hills. The lateral drains should run down the greatest slope and not diagonally across it, unless the inclination be very steep. Oblique drains, however, only drain the land on their upper side, while the straight drains not only take in water from both sides, but also drain the land deeper. This is owing to water lying at a greater depth than the drain coming into them from a higher point, while percolating through the soil. Again, when water is flowing slowly along the oblique drains, it is apt to

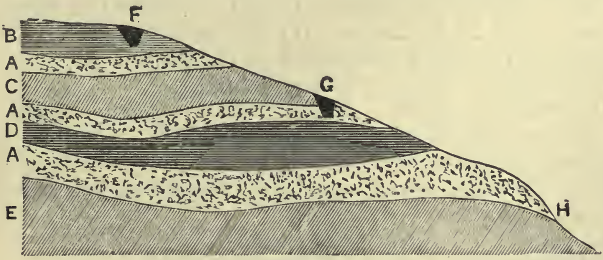


Fig. 46.

pass out at the joints on the lower side, and thus be a cause of wetness to the land farther down the slope.

There may often be seen in some fields dark wet lines, showing that water must be oozing out there from some thin water-bearing strata, A A A, lying between impervious beds B C D E. A trench dug in an oblique manner at F would do no good, while the one at G would only cut through the water-bearing

strata at one place. Should, however, a drain be dug along the surface from F to H, it will cut through the three porous strata A A A, and would convey away all the water.

Should there be any old ridges in the land, which may have determined the course of the water for many years, it is not advisable to cut through them.

Inclination of the Drains.—We have already said that it is necessary to run a small drain into a larger one at an acute angle. An angle of 45° is said to give about the best results.

Drains always require a slight slope from beginning to outlet. Theoretically, the least possible deviation from a horizontal line would cause a flow of water, but in practice the friction between it and its passage retards the progress considerably. A fall of at least one in 220 is needed, but clays, owing to their resistance to the passage of water and air through them, will require three or four times that inclination. Drains filled in with stones or brushwood will require a greater slope than those with tiles.

Should the slope of the drains be too great, as it might easily be in coming down a hill, there is some danger of the water displacing the tiles, and, by flowing out at the joints, tearing up the soil. Collared tiles would to a great extent prevent this, but where it is likely to occur the drains should be laid in an oblique manner across the slope.

Width apart and Depth of Drains.—This subject will be discussed later on. The side drains are from twelve to twenty-four feet apart and three feet deep in clay soils; on light land they may be twenty to forty feet apart and four or five feet deep.

Tools used in Drainage.—(1) An ordinary spade. Used in marking out the drains and taking off the top sod.

(2) Mattock. Used to loosen the soil.

(3) Draining spade. Blade is about twenty inches long, five inches wide at top, and three inches at bottom. Used for taking out the lower part of the trench, and owing to the shape of the blade is well suited for cutting out just enough for the tile.

(4) Shovel. To clear away earth.

(5) Footpick. To cut and loosen the soil.

(6) Drawing scoop. To draw mud out of the drain.

(7) Pushing scoop. To push mud out of the drain.

(8) Tile hook. To string tiles on.

The above are nearly always used, but besides them there may be a levelling instrument to ascertain the best lines along which to take drains, and a boring-rod, used chiefly in Elkington's system, to ascertain the depth of the water-table.

Materials used for conveying away the Water.—Many

substances have been used for this purpose, but pipes are the most common, and much the best. In the Essex system, brushwood, straw, faggots, etc., are used, but they are liable to decay, and although they may do for a time, yet the earth soon falls in and fills up the hole left. Stones, broken to such a size as to pass through a 2½ or 3-inch ring, are sometimes used. Even Smith of Deanstone recommended them in preference to pipes and tiles. Larger stones are sometimes used, set up in triangular or square form, and thus leaving a passage for the water. The following diagrams show various methods of using them:—

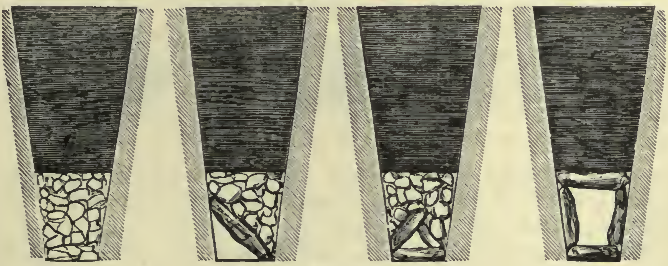


FIG. 47.

In making a stone drain a much larger excavation is needed than with pipes. Again, if the stones have to be carted any distance, their bulk and weight make the carriage expensive. They do not allow the water to flow freely, favour the deposition of silt, and are liable to get out of place.

In draining peaty soils, the peat has been used at first, cut into proper form by a special tool. This is only temporary, but as peat, on being freed from water, has a tendency to sink, it is very useful. Pipes should be put in some time afterwards.

Many kinds of pipes are used; the forms of some are shown in the figures. Brick clay is about the best substance to make them of. It is worked and otherwise prepared in a "pug-mill," and then forced through a specially shaped orifice, the centre of which is occupied by a core equal in size to the hollow part of the pipe. The pipes are then cut into proper lengths by the machine, and taken to the kilns, there dried, and afterwards burned. The pipes are cut into lengths of about fifteen inches, but shrink an inch or two on heating. All pipes must be made of well-tempered, well-ground clay; not too much sand in composition; free from gravel and nodules of lime; well-burnt; straight, smooth, and free from ragged edges. They should give out a clear musical note when gently struck together.

In Fig. 48, 1 represents an oval pipe with feet; a section is also shown. These are a very good kind, requiring little water to flush, and thus deposits of mud in them are not very common. They are, however, not easy to lay, and readily fall over; hence they are not so much used.

Number 2 represents a cylindrical pipe; A is a section of an ordinary round kind, B of one with feet. This kind of pipe is

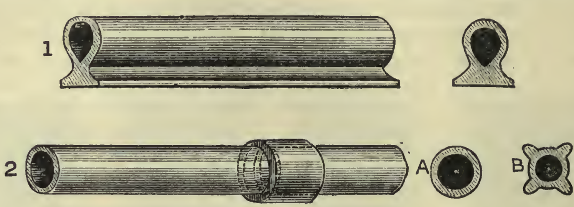


FIG. 48.

strong, fairly light, easily flushed, and quickly carries away water; hence large pipes are scarcely needed in the lateral drains. The feet add much to its stability in the drain. Sometimes the pipes have collars, by which means they fit one into another. Except where they are very liable to displacement, as in peat-mosses, the extra expense is not met by any corresponding advantage.

Horse-shoe tiles were about the first used in drainage, but are rarely employed now. They consisted primarily of a horse-shoe-shaped tile without a bottom. This form was soon found to be nearly useless, as it gradually sank into the soft soil. Then bottoms were made to them. B represents a section of a horse-shoe tile, placed upon a separate flat tile; C has a bottom to the

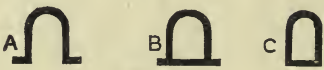


FIG. 49.

tile, and forms a rude pipe. The horse-shoe tiles favoured the slow progress of water, and hence were often filled up with silt.

Size of Pipes required.—Mr. Parkes, once the engineer of the Royal Agricultural Society, calculated that drains 24 feet apart and 4 feet deep, and with pipes of one-inch bore, carried off in a reasonable time a greater rainfall than commonly falls in England. One-inch bore pipes are, however, seldom used now, as they are thought in practice to be insufficient for clearing a field

rapidly of the rain. Two-inch bore pipes are commonly employed for the lateral drains, and three- to six-inch bore pipes for the main drains. The following formula has been given for calculating the size of main drain-pipes from the laterals—

$$M = D \times \sqrt{N} \,.\quad M = \text{main drain.} \quad D = \text{diameter of a lateral.}$$
$$N = \text{number of laterals.}$$

The capacity of pipes varies as the square of their radii.

Commencing Drainage.—It is best to start with the draining of a field soon after harvest, as then agricultural labourers are often out of work, and the ground is in a soft mellow condition.

A good outlet should be first fixed upon. Should the stream into which the main drain opens be of a winding nature, it is generally the best plan to straighten its course first, thus saving land by the operation. The lines which the drains are to take should then be laid out, and marked by removing the turf along the course.

Cutting Drains.—The upper six inches or so of the soil may be taken out with a draining-spade. By means of an ordinary plough the first six inches can be taken out with little trouble, and thus much work is saved. It is usual to commence at the lower end of the main drain, and open that out before anything else is attempted. It should be remembered that the narrower the trenches are in width the better, so long as there is room to get in the tile. From twelve to fifteen inches is about the proper width at the top, lessening down to about nine or ten inches at a depth of three feet. It is often common to then take a piece out of about nine inches deep with the draining-spade and scoops. This leaves a width at the bottom into which the pipe will just fit. On stony land the pick has often to be used, and, as a consequence, slightly wider drains are needed, as the operator will have to stand in them. All small boulders should be removed in order to get a straight line, but when large ones are met they will cost too much to take out, and consequently the drains should be laid in a gentle curve around them. Sometimes, when very deep mains have to be cut, their sides have a tendency to fall in. This should be prevented by means of wooden planks and props.

When finished, the trenches should be examined to see that they have a regular slope at the bottom. In badly cut trenches the bottoms correspond to the surface, and where there is a depression in the land the line of the drain is lowered. When this is the case the water in the pipes will have to flow over hills and hollows, but, as it cannot do this unless under great pressure, it

collects in the hollows, and causes a swampy condition of the ground.

Laying the Pipes.—The pipes should be deposited at convenient places about the field before commencing. They should all be examined to see that none are faulty; bad ones should at once be rejected. The laying should commence at the lowest part of the drain and work upwards, taking care to cover in the pipes laid every day, and not to finish laying the whole field before commencing filling in the trenches. The pipes should have a perfectly smooth bed, and ought to fit closely against each other. The last pipe of each drain ought to be plugged up with hay or straw to keep out all silt. Fine, sandy soil should never be packed next to the pipes, as it readily passes into and chokes them up. When pressing in the soil it is often of great use to run a pole through the last-laid pipes, so as to keep them steady.

Main Drains require to be dug about three inches lower than the rest, in order to get the water to run freely into them. When a large submain runs into the main drain, it is advisable to have a silt-basin to collect all mud. A diagram of one is shown here. It

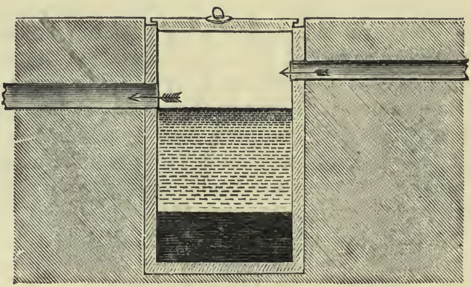


FIG. 50.

should be in the form of a small rectangular chamber, built of stone, and so marked that it may be easily found and cleaned out. It is best to have them provided with a "man-hole," closed by a flag and ring.

Outlets.—As few outlets as possible should be made, as each is a source of weakness. There should, however, be enough to secure the rapid discharge of all water. An outfall should always be faced with stone, so as to protect it. The last pipe ought to be of considerable length, say three feet, and made of glazed earthenware or cast iron. By this it is protected from the frost. At the outer end there may be a hanging iron flap to

prevent the influx of tidal or flood water, while eighteen inches or two feet further up is a hinged grating to prevent the entrance of vermin into the drain. The outer covering is not always needed, but the second is generally required. The water from the drain should fall on a large slab of stone, extending both in front and behind for some distance. By this means, undermining is prevented. A fall of at least one foot on to the slab is necessary, and from there to the river, if any distance away, a uniform slope of about 1 in 150, if possible, should be obtained. When the main drain is about the same height as the river, it is often advisable to carry it some distance along the riverside before coming to a final outlet. By this means the water readily falls into the stream.

Draining Springs.—Should there be any springs in the land, it is advisable to take them off by a separate system of drains, and at a few inches greater depth. Elkington's system is brought into practice in these cases. In draining springy soils that are always wet, it is best to dig only a portion of the depth at one time, to repeat the process at intervals, and to complete the work in the dry weather of the autumn.

Draining Marshes and Bogs.—In draining these low-lying lands there is often great difficulty in getting away the water into the main drain. It is consequently frequently necessary to cut large open ditches, and drain into these. As peat is often shrinking, the lines of drains may get displaced, and hence it is best to dig down to some bed of clay or sand at the bottom, and lay the pipes in these—that is, if the bed is not above six feet from the surface. Pipes with collars would be least liable to be displaced, and hence they should be used. It should be endeavoured, when this cannot be done, to carry off the stationary water by some temporary drainage before laying pipes. It is often advisable to make a bed of clay on which to lay the pipes at the bottom of the trench, and to cover in with clay. This to a great extent keeps the fine silt out of the drains. Should a river be within a reasonable distance, it has sometimes been found to pay to drive a subterranean passage through the ground to it—that is, if enough inclination can thus be got to run away the water.

Air-drains.—Upright shafts are sometimes made to reach the surface from the drains, so that air can easily pass along the drains. By the pressure of the air the water is forced along the drain more readily, and the soil also receives benefit from the thorough oxidation. The soil thus becomes completely pulverized, and a gradual crumbling of both soil and subsoil occurs. From its friable nature, the land would now be much more easily tilled. Theoretically the air-drains would be a great benefit, but there are

several practical disadvantages. There would be the cost of construction, for an ordinary hole cut through the soil would allow much dirt to drop into the pipe, and its sides would soon fall in; hence it would be unsuitable. If on arable land, it would slightly interfere with the cultivation, and, unless well protected by a close grating on pastures, injuries to stock might occur.

Plans.—After draining every field it should be surveyed, and a plan made, on which are marked especially the lines of drains, the silt-basins, and outlets. By means of this, any of these places can be found when required, and hence needless waste of time in searching for them is avoided. Silt-basins and open ditches will require to be cleaned out thoroughly at least once every year, and, being marked on the plan, their position will always be known.

Cost of Drainage per Acre.

	£	s.	d.
Labour of cutting and filling drains at 6*d.* per rod, depth 3 feet	3	13	4
Pipe-laying and finishing at 1*d.* per rod	0	12	2
Cost of 3-inch pipes for side drains, 2420 at 35*s.* per 1000	4	4	8
Extra price for main drain	0	6	0
Carriage of pipes, say two miles, at 3*s.* 6*d.* per 1000	0	10	0
Superintendence of foreman	0	2	0
Outlet pipes and fixings	0	1	0
Plan	0	0	6
	£9	9	8

Cost of Drainage per Acre at Different Widths, Depth Three Feet (Scott).

	18 ft. apart.			21 ft. apart.			24 ft. apart.			27 ft. apart.			30 ft. apart.			33 ft. apart.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Cutting and filling at 7*d.* per rod	4	5	2	3	12	11	3	4	2	2	16	7	2	11	4	2	6	6
Pipes, 14 in. long and 2 in. diameter, at 25*s.* per 1000 ..	2	11	10¾	2	4	5½	1	18	10½	1	14	6¾	1	11	1	1	8	3½
Allowance for mains and outlets	0	3	6	0	3	9	0	4	0	0	4	3	0	4	6	0	4	9
Pipe-laying at ¾*d.* per rod ..	0	9	1½	0	7	10	0	6	10½	0	6	0½	0	5	6	0	5	0
Cartage	0	4	3	0	4	0	0	3	6	0	3	3	0	3	0	0	2	9
Superintendence	0	4	9	0	4	6	0	4	3	0	4	0	0	3	9	0	3	6
Total	7	18	8¼	6	17	5½	6	1	8	5	8	8¼	4	19	2	4	10	9½

ESTIMATE OF LAND DRAINAGE PER ACRE (FROM THE "NORTH BRITISH AGRICULTURAL ALMANACK").

Description of Soil.	Distance apart of Drains.	Depth of Drains.	No. of Rods of Drains per Acre.	Drain Pipes 12 inches long. No. required.	Cost of Cutting and Filling Trenches per Rod.			Total Cost.		
	Feet.	Feet.		Per Acre.	£	s.	d.	£	s.	d.
Heavy Soils—										
Compact, tenacious clay	15	2·6	176	2905	0	0	5	8	0	6
Stiff, adhesive clay ..	16	2·6	160	2640	0	0	4¾	7	2	6
Friable clay	18	2·9	147	2420	0	0	4½	6	7	8
Free, soft clay	21	2·9	126	2076	0	0	4	5	4	3
Medium Soils—										
Clayey loam	22	3·0	120	1980	0	0	5	5	9	5
Marly ,, ...	24	3·0	110	1814	0	0	4½	4	15	8
Gravelly loam	27	3·3	98	1613	0	0	7	5	5	6
Friable ,, ...	30	3·3	88	1452	0	0	6	4	7	6½
Light Soils—										
Light gravelly loam ..	33	3·6	80	1320	0	0	8½	4	16	3
Light marly loam ..	36	3·9	76	1209	0	0	8	4	5	7
Sandy loam	39	4·0	68	1117	0	0	7½	3	3	2
Soft light loam	42	4·0	63	1037	0	0	7	3	7	10½
Sandy soil	45	4·0	59	974	0	0	7	3	3	7½
Light gravelly sand ..	49	4·3	54	880	0	0	10	3	12	10
Deep gravelly sand ..	55	4·4	48	792	0	0	9	2	19	9

Fowler's Draining-plough.—This consists of a low platform running on wheels or rollers very near the ground. It carries a strong coulter, to the lower part of which is fixed a small pointed iron bar. Attached to this, by a hook, is a long wire rope, upon which the pipes are strung. The implement works at any depth up to three and a half feet, and is moved by steam power. In commencing work, a short trench is dug three and a half feet deep, and then the coulter, with tiles behind, is placed in position in this. The rope is drawn along the line of the drain and then pulled out, when the pipes are left in position. Another similar start is then made.

The objection is, that the friction on pulling the pipes through the land is very liable to break them.

The Mole Plough.—It consists of a wrought-iron framework working on or near the ground, and provided with a strong sharp coulter, about two feet long and six inches broad. At the lower extremity of the coulter is a sharp wedge-shaped sock, to which

is connected, by a couple of links, the oval-shaped iron "mole." This is about twelve or fifteen inches long, three or three and a half inches wide at the base. The work of mole-drainage should be carried out in the wet winter weather, as then the land is softer. A hole is dug for the plough to start from, and it is then pulled up and down the field by an engine. The depth of the drain is about two and a half feet; it consists of a slit, at the bottom of which is a cylindrical hole, three or three and a half inches in diameter. In order to prevent earth falling into the drain the slit should be covered over at the surface with a furrow slice. The drains are about a rod apart. At the lowest part of the field is a main drain, at the bottom of which is a line of pipes or some brushwood. Small pipes lead off alternately for a short distance into the mole-drain, and thus the two are connected.

Mole drainage is not permanent, lasting only from ten to twenty years; hence it may be a tenant's work, but rarely that of the landlord. It is cheap, the cost being from £1 to £5 per acre. Mole drainage is efficient for the time mentioned, and keeps the land as dry as required. It can be performed on permanent pastures with little injury, and hence is a useful operation there. The openings are, however, liable to collapse in time, and the various small animals frequenting pastures, etc., such as the mole, often destroy the track. Stiff clays are best suited for mole-ploughing, as the opening will remain in them for the longest time.

Wedge-and-shoulder Drains.—While treating the subject of drainage without the introduction of any foreign material into the

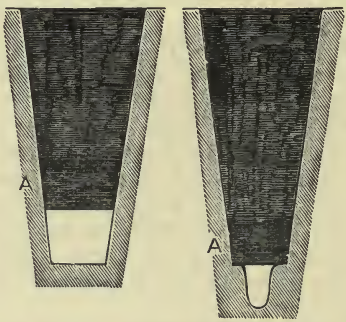


FIG. 51.

soil, we might as well notice this system, which is not commonly met with now. A trench is cut, and then a surface sod, A, is cut and pressed in, grass downwards. The sod is of such size that it cannot reach the bottom of the trench, and consequently a hollow space is left, which allows the water to run away for some

time. The operation is very temporary; as a rule the hollow is filled up. Wedge-and-shoulder draining would not be of much service on arable land, as the plough would gradually destroy the drain.

Plug Drains.—These resemble the wedge-and-shoulder drains greatly. A trench is cut with good smooth sides, and then a string of wooden blocks, fastened well together, is laid along the bottom. The blocks are of any desired shape, so as to get a certain form of drain. The earth is next returned to the drain and beaten in well, the block being gradually moved forward by means of a chain and lever. When finished, there is a hollow at the bottom of the trench corresponding to the form of the blocks. Plug drains last longer than ordinary wedge-and-shoulder drains, but the objection to them is, that the earth being tightly pressed in, prevents the water entering the drain.

After Management of Drains.—If the drainage has been on pasture land it should be endeavoured to return the sods as nearly as possible to their original position, and, a short time after, a heavy rolling should be given.

Silt-basins will often require to be cleaned out; and the outlets should be attended to so as to prevent their being blocked up in any way. Sometimes a pipe may be choked with dirt falling in through some improperly connected joint. This would prevent the flow of water, and would cause a dark damp appearance of the vegetation. When this is seen, the cause should be searched for and removed. It is sometimes necessary to open into the drain and take the material away. Flushing the drains with water will often remove bodies blocking up the pipes.

In order to assist drainage on stiff clays, deep cultivation is needed, and, for this purpose, subsoil ploughing, performed a year or two after drainage, answers very well. The soil is opened up, and water more easily percolates through it.

Old Drains.—After a long time, drains sometimes get out of place through some subsidence of the ground. If not attended to, the injury slowly increases, and at last an extremely damp state of ground is produced. The higher part of the drain will still convey water, but only to the place where the dislocation has occurred. Sometimes, in very old-drained land, the drains have got thoroughly out of place, and a fresh drainage is needed. In this case the old pipes must be all dug up before starting.

Reciprocal Action of Drains.—By this is meant the assistance which neighbouring parallel drains give to each other.

The diagram on next page represents a section of a stiff clay soil in which drains are first placed at the distance EE′. Owing to the texture of the clay they will have but a limited influence, and this

is represented by the dotted lines EA, E′B. These lines, it will be observed, do not meet, and hence the space between A and B is left almost as wet as before. Now let drain F be introduced about midway between other two. The influence of this drain will be felt from H to G, and AB is properly drained. But the distances HA and BG on either side are now drained by E and F, and E′ and F respectively, and hence the united effects exert great influence on it. The soil will be dried quickly, and, by the alternate rapid wetting and drying, it becomes completely pulverized. In this new condition it much more readily allows water to percolate through it and run off by the drains, and also

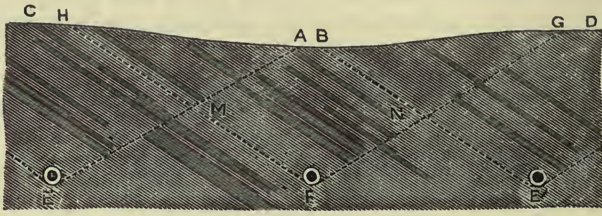


FIG. 52.

the influence of each drain becomes felt over a greater surface. The soil, otherwise untouched by the drains, becomes affected by the pulverization of the rest, and to a certain extent becomes freed from water. The points M and N, at which water formerly stood in the soil, are lowered, and thus the depth of soil available for plants is considerably increased.

The character of the soil to a great extent limits the benefit derived from "reciprocal action." A gravelly soil, even when drained, is not very much altered in texture. It was always a light open soil, almost drained as well naturally as it would be artificially, unless there was some impervious sublayer, retarding the progress of the water. In such a soil as this, a single drain assists very greatly in carrying off the surplus water of a field, and a well-arranged system has been known to completely drain land quarter of a mile away. In a stiff clay, a single drain would be of no use whatever. It might take away a little water, but enough would soak through to prevent it doing any good. But in a proper series of parallel drains one assists another, and thus, through the reciprocal action, the friction, which before prevented the water from passing freely through the close-set particles, is overcome.

The Depth of Drains.—This is a most important subject in drainage, for upon it much of the success of drainage depends.

The chief point affecting the depth of drains is the character of the soil. A clay soil has its particles closely set together, and retards the downward passage of water greatly. It is wet from top to bottom, and in such soils the drains will need to be near the surface, and close together. By this means the reciprocal action is fully secured. On light soils it is best to have deep drains. Such soils are wet from bottom to top, and hence a deeper drain would not only run off more water, but would sooner begin to flow. To explain this, take a hollow cylinder with one end closed, and bore a couple of holes in the side, one a few inches below the other. Now pour water into the cylinder; of course the lower hole allows the water to escape, while the top one has little or no effect. The action in the light soil of deep and shallow drains is similar. In a stiff clay, water comes into the drain chiefly from above, but in the ordinary class, from below; hence deep drains are, as a rule, the best. Above the water-table it will have been noticed that there is a certain depth of land wet from capillarity, and, on account of this, it has been recommended to dig deep drains in clays as well as in light land. The tenacity of the clay would, however, prevent the water from running freely into drains laid at too great depth.

The cost of cutting the trenches is an important consideration. Sandy soil is easily cut and thrown out of the trenches, and the pick has rarely to be used. In many places the digger need not get into the trench, being able to work it from the surface. In such soils the expense of cutting is small, and this is another reason why deep drains should be the rule. In stony soils there is often great expense in removing boulders, and the depth is somewhat regulated by the presence or absence of these. On clay land, the process of cutting drains is very expensive. The soil is generally so tenacious that the pick is frequently required to break it up into suitable pieces. Also the labourer has often to stand in the trench, and in order to do this a wider trench is required. An extra foot in depth of a drain means a considerable extra expense, amounting to about half the former cost.

All drains must be out of the way of tillage implements. It is not, however, often the case that they are injured in this way. It is necessary that the roots of plants should have sufficient room in which to grow. Sometimes drains have been laid of such a depth as to prevent shallow-rooted plants from reaching the stratum wet by capillary attraction, and in consequence they have suffered greatly in droughts. Many plants have roots four or five feet long, and for such as these there is nothing to be feared, as they have often been found to reach and fill up the drains at that depth.

On clay soils two and a half to three and a half feet is quite sufficient depth, and the drains should be proportionately close. Loamy soils may be drained at a depth of about three and a half or four feet, and light soils four to five feet. On peaty soils it is advisable to cut down upon some solid foundation, such as a bed of clay,—that is, if not above five to seven feet deep. When a water-bearing strata is discovered, it should always be cut down to, if at a reasonable depth.

Sometimes cracks may be observed in the land. It should be endeavoured to get the drains at a greater depth than these, as a shower washes a quantity of fine soil through them into the drains, soon blocking them up. Again, the pipes should be deep enough to prevent the rain from washing through the soil, and removing valuable constituents.

Draining at Wide and Narrow Intervals.—A tenacious soil, by preventing the free percolation of water, requires the lines of drains to be frequent. A light soil, however, allows water to rapidly pass through it, owing to the coarse texture. A drain in such land exerts a considerable influence on both sides, but, as stated before, the influence of one drain in a clay land is scarcely felt. It should always be endeavoured to secure reciprocal action to the greatest extent possible. It is a great mistake to make drains too wide apart; even on light land, sixty feet is about the maximum distance to be allowed. Greater distances allow wet patches between the drains. On clay lands, owing to the cost of cutting, many farmers make their drains deep and wide apart. To a certain extent this is all right, but it is much better to have the drains fairly shallow and near together.

On a stiff clay, twelve to fifteen feet between the drains is sufficient; on loam they may be twenty to thirty feet apart, while on sandy soils forty or fifty feet apart may be allowed.

According to Stephens, a light-land drain will dry on each side of it a distance of from five to six times its depth; in medium soils, four or five times; and in clay soils two or three times.

Length of Drains.—Scarcely any rule can be put down as to the length of drains. It may be taken, however, that for side drains long ones are preferable, while mains should be short. The reason for this will be easily seen. The water in the drains has no force to move it along except its own weight. Hence, on nearly level lands, the water collects in the drains until such an amount is gathered as to cause a constant run. With a long drain this result is sooner accomplished than with a short one, unless the latter drains off some spring. The constant flow of water also prevents any deposition of sediment which might otherwise take place.

A long main drain collects water from a considerable number of laterals and submains, and to lead into one main the drainage of a large tract of wet land often gives it too much to carry away. The result is a block in the system, sometimes causing displacement of the pipes.

Geological Considerations involved in Drainage.

The drainage of the land must to a great extent depend on the geology of the district. On such land as the London clay, the drains must be close together and not very deep, but on the Bagshot Sands, which cover part of it, the reverse must be the rule. When several strata alternate, the land frequently requires the drainage to be on Elkington's system. Many flat alluvial soils are very difficult to drain owing to their level character, and long open trenches have often to be cut to empty the water in. In some cases a porous water-bearing stratum may nearly come to the surface at a particular point and then go down deeper. If a drain could be dug into the stratum at this point the drainage of the lower part of the field would be rendered much easier.

Fertilizing Matters abstracted from the Soil by Drainage Water.

Water, in passing through the soil to the drains, dissolves out small amounts of mineral salts and plant-food, which it carries away. The greater the absorptive power of the soil, the less will be the amount thus lost. Nitrates and chlorides, being very soluble, are among the salts lost in greatest amounts, and, owing to the value of the former, the loss is often serious. Ammonia, potash, and phosphoric acid are not often found in drainage water. They are retained chiefly by chemical affinity, in a loose sort of combination with other substances. Ammonium salts, such as the sulphate, are not so soluble as nitrate of soda and other nitrogenous manures, hence they are not so readily washed away.

Sandy soils, from their small chemical retentive power and their free nature, are very apt to lose large quantities of valuable salts by drainage water. Clays, however, are much the reverse of the last.

When drains are near the surface, the rain quickly washes through the soil, and thus there is a greater chance of loss of plant-food. There would be more chance of this happening in light land, consequently this is another reason why drains should be deeper in light soils than in clays.

The amount of nitrogen lost in drainage waters from

Rothamsted experiments varies from 36 to 46 lbs. per acre per year. This is much more than that removed by 30 bushels of wheat or 40 bushels of oats. On pastures and meadows the amount will be considerably less. About $3\frac{1}{2}$ parts of nitrogen and 6 parts of chlorine per 1,000,000 of drainage water were lost from unmanured plots growing wheat, but these amounts are greatly increased when plenty of manure is applied.

CHAPTER V.

IRRIGATION.

IRRIGATION consists in allowing water, with fertilizing matters in it, to flow through a soil, and then in draining it off as quickly as possible, allowing no sediment to be deposited. In *warping* the water is allowed to deposit any matter it contains upon the land, thus causing an increased depth of soil.

Reasons for Irrigation.—All plants require a considerable amount of water to carry on their healthy functions. In droughts, irrigation is found on this account to be very beneficial. Various constituents of plant-food are taken up by the soil from the water passing through. Nearly all the ammonia contained by sewage is thus absorbed when filtering through the land. Again, water is often warmer than the soil, and thus the temperature of the land is raised somewhat, and as a consequence the crops mature earlier. The increase in temperature has been reckoned at 10° Fahr. in spring. Air follows the passage of the water, and the good effects of oxidation in the soil are well known. Bad grasses are said to be lessened, and the finer qualities grow much better. Irrigation causes a considerable amount of matters to be dissolved out in the soil, and these act as active plant-food. On the other hand, however, too much water may wash away valuable soluble constituents.

Various Qualities of Water employed.—It might be supposed that muddy water would be the best for irrigation purposes, but this is not the case as a rule. The mud and sand would settle down on the vegetation, and prevent its proper growth. On arable land, not growing a crop, such water would be very suitable, as it forms fresh layers of soil. This, however, more resembles warping than ordinary irrigation. Clear spring water is the best, especially that which has to percolate through thick beds of rock, as then it more readily dissolves out plant-food.

That coming from limestone districts, and consequently containing a fair amount of carbonate of lime dissolved in it, is very useful for irrigation. Sewage water, when obtainable, is of the greatest value, as it often contains large amounts of organic and inorganic matter, useful as plant-food. By the aid of sewage, four to six crops of grass, of from ten to fifteen tons each, can be obtained from meadows. Hard water is better than soft, as it contains more dissolved mineral matter. Water from peaty and boggy soils often contains sulphate of iron in solution, and has then injurious effects. If passed over some calcareous soil before flowing over the meadows, nearly all the iron is deposited. Sea-water should never be used, as the large amount of salt it contains has a tendency to destroy vegetation.

Soils Suitable for Irrigation.—A stiff soil, owing to its great retentive power, is not well suited for irrigation. It would be apt to become waterlogged, and injurious effects would result. Sandy or gravelly soils allow water to readily pass through them, and, as they are naturally dry and of poor quality, they would be greatly benefited. Before irrigating any land it must be thoroughly drained, otherwise the water does not readily flow away, and a swampy condition is the result. Of course, in dry seasons irrigation will be of more value than in those in which there is an abundance of rain.

One acre of land is sufficient for about a hundred people, each producing twenty-five gallons of sewage daily.

One acre is needed for from five to ten head of cattle; the urine being diluted with twice its bulk of water.

Suitable Crops.—Nearly all grasses may be used, but rye grass, especially Italian, gives the best results. A few of the fodder crops are irrigated, but the meadows are generally the only parts treated.

Mode of Action.—A steady flow of water should be produced, and the intervals between the periods of flooding should always be long enough for the land to get rid of all superfluous water. A shallow current moving at a fairly rapid rate over the ground does most good. Irrigation is said to cause an increased amount of roots to the plants, hence we see one reason for the larger crops. The plant can search for its food through the soil more thoroughly, and thus makes better use of the materials contained by the sewage. The various changes produced by irrigation in the soil have already been noticed.

General Management.—It should always be remembered never to leave the water on the land for more than a fortnight, or else nothing but aquatic grasses and plants will be able to grow on it. Sometimes a white scum appears on the surtace of the water on

the land. Whenever this is the case, the field should be cleared as soon as possible. This scum, if allowed to settle on the grass, clogs it up and kills it. At least two days should elapse before another flooding is permitted after drawing off the last. In frosty weather, when it is required to run off the water, the operation ought to be performed in the morning, so that the land may be dry before night; otherwise the vegetation would be very wet in the evening, and liable to be destroyed by the frost.

After drawing off the water, stock should not be placed on the land at once. Sheep will be able to go on before cattle, as they will not hurt the land so much. In autumn it will not always be safe to put sheep on the land, as they are liable to attacks of foot-rot and liver fluke.

When intended for hay, the grass on the pastures is cut in May or June. As irrigated grasses usually contain a large percentage of water, there is considerable difficulty in drying them, and hence it is best to sell or use it as green fodder, or make it into silage. The land is flooded as soon as the crop is taken off, and a second cutting soon follows, in about four weeks, weighing sixteen to twenty tons per acre. Another flooding takes place after clearing away the crop, and then cutting and flooding succeed each other till about October, by which time from four to eight cuttings have been obtained.

Times of Flooding.—In January and February the land may be flooded in frosty weather for protection, but avoid running more water on to the sheet of ice which may have formed on the surface of the previous flooding. To prevent a scum forming, the water may be drawn off in the morning and put on again in the evening. The land may be grazed when dry from February up to April, and then flooded well for the hay crop. After getting the hay or fodder in May, the farmer may graze off the aftermath with cattle, and flood occasionally in dry weather. If the land is to be used for the production of forage, the water should be turned on soon after cutting each crop. In November and December the meadows will need to be often watered. It should be always remembered that the water ought to be kept running over the land, and that it should never be allowed to become stagnant.

Relative Advantages of the Various Systems of Irrigation.

The two principal modes of irrigation are by Catchwater meadows and Flow meadows.

Catchwater Meadows.—This plan is practised chiefly where the land has a slight slope, or where the ground is irregular. An

open ditch is dug across the top of the field, and banked up with turf until the water in it will be able to rise at least a foot above the rest of the field. Water is run into this ditch from the river either by making a trench to it from some higher place in the river's course, or by making a dam, and thus raising its height. The contour lines, or lines of equal level in the field, are next found. Small gutters, about three inches deep, are then dug along these lines at distances of thirty or forty feet apart. These are called feeders. The water is admitted into the feeders from the main carrier, and flows along them until they are full. It then passes over the sides and spreads over the inclined table, passing into the next gutter, from which it again overflows, and so on to the bottom of the field. The water is caught by catchdrains at the sides to some extent, but finally flows into the main drain, running along the lowest part of the field. The main drain is nearly similar to the main carrier, and runs into the river at some lower point.

Flow Meadows.—This system is practised on fields nearly level. The land is first ploughed into ridges ten or twelve yards broad, in the direction of the greatest slope. The ridges are from six inches to a foot higher at the crown than at the sides. The main carrying-trench runs along the top of the field, and from it there run off numerous leaders, one going down the centre of each ridge. These leaders are from eighteen to twenty-four inches wide at the commencement, and diminish gradually to about six inches. Between the ridges are carrying drains, narrow to commence with, then gradually widening out, until, when they run into the main drain, they are as wide as the feeders are to begin with. The water runs into the leaders through sluices, and, owing to their beds gradually contracting, it flows over the sides in a thin sheet. The water which runs off is carried away by the carrying drains into the main drain, as in the previous system. When the ridges have a considerable slope the water is apt to run to the bottom of the feeder too quickly, and thus the top part of the field does not get irrigated. In order to prevent this, "stops" are put in, which check the flow. The "stops" consist of pieces of turf left uncut at the bottom, or of stones or small boards put into the trench, and thus raising the water a few inches above its height previous to the operation.

Advantages of the Two Systems.—The catch-water system, when applicable, seems to be the better of the two. It costs less to construct the trenches, etc., allows the water to be run off the land quickly, and the land to dry rapidly. With the flow system a considerable cost is incurred at the beginning, through having to form the land up into ridges. The catch-water system is much

the best on sloping ground; on such land the flow system would allow the water to run off by the trenches without benefiting the land. On the other hand, on nearly level ground the catch-water system would not act, as there would not be sufficient slope for the water.

Quality of Herbage.—As might be expected, irrigated grasses generally contain more water than others. They have a greater chance of getting moisture, and also have to take up their food in a very dilute solution. If used young, the grass contains most of its solid matter in a soluble form; but if allowed to ripen, it will contain more solid matter, though not so soluble as before. The luxuriance of the growth causes the later crops to be rather coarse. The nitrogenous part of the solid constituents is said to be increased in sewaged grass. A greater amount of milk is got from its use, but the percentages of the different constituents are lower than usual, except in the amount of mineral matter. In pastures the application of sewage seems to cause the development of grasses at the expense of the clovers. Many innutritious grasses and moss are said to disappear from irrigated meadows. Of course, if the land is not properly drained and is in a swampy condition, various aquatic plants will grow, and take up the places of more valuable ones.

Sewage.

This has been treated on to some extent in the preceding pages on Irrigation. It is of more use than ordinary river-water, but as it can only be obtained near towns, its application is limited in extent. It is generally applied by the flow system, the amount given varying greatly. At the sewage meadows near Edinburgh, as many as six or eight crops of grass are obtained yearly, and thus town dairying can be carried on.

Sewage is used in two forms, Raw and Clarified. The former is the kind most generally used, and is sewage just as it comes from the towns. Clarified sewage has had some chemical substance added to it to cause the precipitation of the solid matters it contains. Alum, blood, and clay are most often used. The resulting compound is, of course, of much greater value than ordinary sewage, but is still not worth much. (See "Native Guano" in the chapter on "Manures.")

Sewage contains six to eight grains of ammonia per gallon, and also small amounts of phosphoric acid and potash. The total solid matter varies from about seventy to a hundred grains per gallon, as a rule. Of course the more water the sewage contains the less is its agricultural value. If the sewage has to

be conveyed any distance, the cost of application amounts to more than the value of the manure. The small amounts of fertilizing matters it contains gives it an exceedingly low value. Thus it has been reckoned by some authorities at from $\frac{1}{2}d.$ to $4d.$ per ton, and the highest value given to it seems to be only $10\frac{1}{4}d.$ per ton. But besides its chemical value, sewage has an indirect use, although this cannot be reckoned at a money value. From an analysis, sewage will be seen to be of little use as a direct manure. It contains too little of plant-food constituents, and the abundant crops obtained by it can only be explained by its power of rendering soluble some of the mineral constituents of the soil.

Sewage is said to have the effect of driving away many injurious insects and grubs, such as the wireworm, various beetles, slugs, etc. Should, however, the grass become rank, probably more insects would be sheltered than got rid of. The crane fly would very likely become numerous, and act injuriously.

The quality of herbage obtained by sewage is very similar to that obtained by ordinary irrigation. It is, however, rather coarser and more bulky, owing to its growth being more forced.

Ten tons of sewage have been found to contain :—

In solution	Nitrogen	1·7	= 4·2 lbs.
	Phosphoric acid ..	0·4	
	Potash salts	0·5	
	Soda salts	1·6	
In suspension	Organic compounds ..	1·4	= 1·9 lbs.
	Nitrogen	0·3	
	Calcic phosphate ..	0·2	

Total = 6·1 lbs. per ten tons.

Warping.

This operation is still more limited in the extent of its use than irrigation. In England it is chiefly confined to the Holderness in Yorkshire, parts of Lincolnshire, and around the Wash. There the rivers Ouse, Trent, Witham, Welland, Nen, and Gt. Ouse flow, in an extremely sluggish manner, into the sea. They generally contain various matters in suspension in considerable quantities. These matters they, in the ordinary course, deposit in their beds and at their mouths; but if turned on to the fields they leave much of their mud there instead.

Before commencing warping, the land requires to be embanked, so as to confine the water upon the proper part. The banks are from three to seven feet high, and enclose up to 150 or 200 acres. With large fields, or those some distance from the river, a canal is dug from the river through the land.

From the canal, if a long one, there runs a drain into each compartment. Its exit from the canal is closed by a sluice, and thus water is let into it at pleasure. The water is run from the canal over the land by small channels or "inlets." These soon overflow, and the water gradually spreads over the land, depositing its mud. The land is only flooded at high tide, and is drawn off at low. The return of the water tends to clean out the channels of any mud deposited in them. About one-eighth of an inch of warp is deposited at each tide. The operation begins in June and ends about October, never being performed during winter. In this it differs from irrigation, which gives good results in the winter months.

Contrary to what might be expected, warping during floods is of little value, and in the driest time of summer the best results are obtained. It is said that during the greatest droughts warp is best and most plentiful. During the season, from six inches to three feet of new soil may be thus obtained. The warp, when deposited, is in a state of very fine division, and is found on the land in layers; that mud derived from each warping being distinct. The stiffer the warp is, the better it is said to be.

The chief difference between irrigation and warping is that, with the former, it is chiefly the water which produces a good effect, in the latter it is the mud. The former operation manures the land, the latter forms fresh soil; consequently a barren sand derives as much benefit from warping as a rich clay. The good effects of warp are well known. The Holderness, consisting chiefly of this alluvial mud deposited in a natural manner, is nearly the richest land in England, and the soil got by warping is similar to it. In Egypt, where we see the operation carried out on a large scale, enormous crops of grain can be raised on the same land year after year with little or no manure. In England eighty bushels of oats per acre are often got on warped land.

Warping is said to carry the seeds of weeds to the land, which previously were unknown there. Amongst the chief ones brought in this way there are mentioned mustard, cresses, and wild celery, with plenty of docks and thistles. They are brought from higher levels.

Warping is, of course, only applicable to arable land, and no crop must be upon it at the time. If attempted on pastures, the deposit would choke the herbage. On some parts of the alluvial soils of Lincolnshire enough mud has been deposited in a natural manner to remove all necessity of warping. The operation, however, is of great use on any poor soil at a convenient distance from a river, and at such places ought to be carried out.

CHAPTER VI.

PERMANENT PASTURES.

At the present time, when wheat sometimes hardly pays for the expense of growing, it is not surprising to find that a large extent of land, on which wheat was formerly grown at a profit, has been put down to permanent pasture. This is especially the case with heavy clay land, for the following reasons: first, on account of the expense and difficulties in working clay land; secondly, the low price of corn; thirdly, the special adaptability of this class of land for permanent pasture. There is no doubt that the amount of permanent pasture has increased in the country to a very great extent. The following may be regarded as arguments in its favour.

(*a*) Less expense in working.

(*b*) Production of beef, mutton, and dairy produce pays better than corn.

(*c*) Near a town hay pays better than corn.

The drawbacks to permanent pasture are—

First the outlay to begin with, and loss from unproductiveness during several years, until the permanent pasture gets well established.

It is well known that in laying down land to pasture a full crop is often got the first or second year, and then the pasture generally falls away for several years in succession. It begins to improve gradually for fifteen to twenty years before it arrives at the condition of good permanent pasture. The causes of this we will inquire into presently.

Another objection is, that there is not sufficient encouragement to tenant farmers with short leases to go to the expense of forming permanent pasture.

Another objection to the increased amount of permanent

[1] This chapter is from a lecture delivered by the late Dr. Webb.

pasture has been raised by arguing that it is a retrograde movement; that in this age of science and free education it is humiliating to have to give up tillage and return to primitive pasture. Cannot the resources of improved machinery and science help us? Of course they can; but our competitors have as good machinery and scientific knowledge as we have, with the further advantage of a merely nominal rent, a better climate, and the co-operation of the great steamship and railway companies, which will actually bring agricultural produce a thousand miles from the interior of America to the coast, across the Atlantic Ocean to Liverpool, and from Liverpool to London—all this at a cheaper rate than the same amount of agricultural produce can be brought from Scotland to London.

Others have opposed the laying down of permanent pasture from politico-economical reasons. They say that laying down to grass to any extent will tend to depopulate the rural districts. The farm labourers will either overstock the towns with unskilled labour, or go abroad to swell the ranks of our competitors in wheat-growing.

Many other secondary evils have also been predicted, but there is no cause for alarm. The amount of permanent pasture may increase in those districts where most suitable, and the amount of wheat grown may become less, but arable land will always be necessary. Also, if the amount of land under permanent pasture continues to increase, a point will soon be reached when arable land will pay better than pasture, so that the disease is its own remedy.

At the present time, no doubt, a great deal of land might be laid down to permanent pasture with advantage, especially under the following conditions:—

1. Where labour is dear.
2. Where land is expensive to work,
3. And suitable for permanent pasture,
4. With a long lease and a good landlord to assist. Some landlords pay the cost of the seeds.

Selections of Land for Permanent Pasture.—Some soils and climates are more suited for permanent pasture than others. Thus the west of England has generally a moist climate, which causes an abundant growth of grasses. A sharp sand or gravel gives a bad soil, as it affords little plant food, and is too apt to get dried up. A strong loam or clay is most suitable. The aspect has something to do with the adaptation. Thus, fields facing the north do not dry up as soon as those with a southern aspect. A good supply of water, if possible, should be obtained.

Drainage.—The first thing to be attended to must be the drainage.

Some lands which are naturally drained, like many sandy and gravelly soils, require no draining, unless they are upon a retentive or clay subsoil, from which water rises by capillarity. The distances and depths of the drains will vary according to the land; but the land should be drained at such a depth that the bottoms of the hollow in the fields may still be moist, and yield a slightly different variety of grasses from that on the ordinary level. (See the chapter on "Drainage," p. 364.)

Preparation and Cultivation of the Land.—If cleaned by means of a root crop, the land should be thoroughly hoed and stitch grubbed; and, in previously preparing the land for the root crop, the cultivation should have been deep, to provide plenty of feeding ground for the coming crop.

Methods of seeding down.—Seeds may be sown in the usual way with barley or oats (according to the district), on a very fine and well-prepared seed-bed, lightly harrowed, and then rolled, either before the corn germinates, or soon after it comes above ground. Seeds are generally sown about April. Experience in the district will determine the best method, but the idea should be to give the seeds rather a better chance than usual.

The barley or oats, or in some cases wheat, with which the seeds are sown should grow straw of a stiff character, so that they may resist the wind and rain, and not become laid. In order that the seeds may have a better chance of growing, the corn should not be sown too thickly.

Sometimes the seeds are sown with rape, but, in the opinion of many good judges, this practice is more suitable for alternate pastures, where only the stronger varieties are grown.

For laying down clay lands, it has been found advisable to summer fallow, deep plough, and continually grub, harrow, and roll. Then sow the seeds without a crop in the following spring. This plan is often recommended by seedsmen, although it is seldom adopted by tenant farmers, for obvious reasons. Still it is the safest way of getting seeds to grow well. They do not stand the chance of being smothered by the growing corn crop, and the finer grasses stand a better chance of flourishing.

Mr. C. Randell, of Chadbury, Evesham, in a paper on the "Laying down of Clay Land to Pasture," published in the *Royal Agricultural Society's Journal*, says—

"It is absolutely necessary, in laying down land to permanent pasture, that the land be thoroughly drained.

"The first thing to do is to get the land free from couch grass; and if, as was the case in 1881, this can be effected by the aid of

steam in June, and there be a sufficiency of rain afterwards to get a fine natural tilth in July, the grass seeds may then be sown; and, if aided by five hundredweights per acre of fish guano, containing 8 to 10 per cent. of ammonia and 35 per cent. of phosphates, or the equivalent thereto, the grass seeds will be established before winter. It may be that they will be required to be eaten off carefully in September. If the land cannot be got ready for the seeds by the end of July, the sowing will be done in the following spring without a corn crop, upon a stale furrow, merely scarifying the land to get rid of surface weeds.

"The mixture which I have used is—

"1 bushel cocksfoot (to 1½ bushels, according to percentage of growth).
½ bushel perennial rye-grass.
6 lbs. cow-grass.
2 lbs. Dutch clover.

"This mixture costs from about 15*s.* per acre.

"Having secured the grass plants, the next consideration is how to treat them; and here my view will be opposed to those generally entertained. The prevailing idea is, that no sheep should be allowed to go upon newly laid land.

"I would have no other stock for the first three years, but in this way:—Assuming that the seeds are sown in July, the tilth and the weather favourable, they should be so strong in September as to require to be eaten down, otherwise they would be liable to injury from frost before spring. This should be done by lambs folded upon them, and giving as much space twice a day as they will eat level, with an allowance of oilcake, malt-dust, and clover-chaff. The back hurdles should be moved every second day, to prevent the lambs biting off again the young seeds as they spring, and they must not be upon them in wet weather. To avoid this, there must be a field of turf or old seed to take them to when their treading would injure the young seeds.

"In the following spring these young seeds should be folded off by ewes and lambs, the latter going forward by the aid of lamb-gates, and both getting pulped mangolds mixed with chaff and oilcake (linseed and cotton-seed, mixed); the back hurdles should be frequently moved, for two reasons—(1) that the land should be equally manured; (2) that the young shoots of the grasses be not eaten down again immediately. A second folding may be made with yearling ewes; a third with the general flock, each lot receiving half a pound of cotton cake daily, but none kept on the land after October. If this treatment be repeated the third year, the turf will be well established; but the less it is stocked during winter for several years the better.

"If a crop of corn is taken the first year, which would usually

be the case in the hands of a tenant, the same method should be adopted in eating off the young seeds: but it will not often happen that they require to be fed off after harvesting the corn crop; if they do, it should be done by folding, not by turning sheep into the whole field."

Selection of Seed.—(1) Note the grasses that are natural to your neighbourhood, found by the roadside, or in fields that have laid themselves down, or in old pastures.

Then use only the best of these naturally growing grasses. This is the only safe way; for there are so many circumstances determining the character of the soil and climate, that no seedsman can tell with accuracy the kind of seeds best suited to a particular district.

See that you get grasses which will produce food at different times of the year. For instance, cocksfoot and foxtail come first in spring; then rye-grass, timothy; and, lastly, crested dog's-tail, the fescues, and yellow oat-grass.

In pastures that have been carelessly laid down, food may be rich at some parts of the year and dried up at others. This shows the necessity of having a large variety of good grasses.

The Purchase of Grass Seeds.—Buy your seeds with a guarantee of purity and germinating power some time before you intend to sow. Have your seeds delivered in separate lots (unmixed), get them tested, and then mix for yourself. Never buy seeds ready mixed. Mix grass seeds first by themselves, and then add the clovers and timothy, because these, being heavy seeds, would have a tendency to sink to the bottom if mixed too much.

Grasses for Permanent Pastures.

Tall Grasses (Perennial):—

1. **Meadow Foxtail** (*Alopecurus pratensis*) produces an abundance of keep, and has a very succulent and leafy growth, extremely palatable to all kinds of stock, and also very nutritious. Even the heads that have run to seed are eaten off. It flowers in April; germinating power, 40 to 50 per cent. sometimes, should never be lower than 20 per cent.; weight of seed per bushel, 5 to 14 lbs.

2. **Cocksfoot** (*Dactylis glomerata*) is one of our most useful meadow grasses, growing best on deep rich loams; it will bear the shade of overhanging trees. It, however, suits most soils, and will bear drought well, owing to its deep roots. It gives early spring and late winter feed, much relished by stock, and also very nutritious. Although it looks coarse it is perhaps the most valuable of all cultivated grasses. It has a tendency to get too coarse and tufty on some light pastures. It flowers mostly in June; germinating power, 90 per cent.; weight per bushel, 20 lbs.

3. **Timothy, or Cat's-tail** (*Phleum pratense*) is another first-class grass, yielding a most palatable, nutritious, and plentiful food for stock. It affects clay soils, and yields abundant leafy growth, sending up its seed-stems rather later in autumn than most grasses. It is a good grass for hay. The seeds are nearly free from adulteration, as they are easily discriminated. They are very heavy and very small, often sown with the clover, as they do not mix readily with other seeds. Time of flowering, end of June; weight of seed per bushel, 48 lbs.; germinating purity, over 90 per cent.

4. **Meadow Fescue** (*Festuca pratense*) is a later grass than the others. It prefers stiff soils, where it produces an even and nutritious growth of most abundant herbage. It is nearly twice as valuable when cut for hay in flower than when the seeds are ripe; but, as it does not seed until early in August, this will not affect it much. It is often adulterated with rye-grass, as it costs tenpence per pound, while rye-grass can be bought at about threepence. Weight of seed per bushel, 28 lbs.

5. **Tall Fescue** (*Festuca elatior*) generally succeeds wherever meadow fescue will. It is probably the same grass altered by cultivation. It is a coarser plant with a tufted growth; and, though willingly eaten by stock, it is not to be sown in preference to the species last named. Time of flowering, first week in July; weight of seed per bushel, 25 lbs.

6. **Golden Oat-grass** (*Avena flavescens*) is always found in the best natural pastures. It is a late grass, and succeeds well in dry soils and upland pastures. Seeds are very dear, often 3*s.* per lb., and in consequence it is often adulterated. Germinating power, 60 per cent.; weight per bushel, 10 lbs.

Small Grasses:—

7. **Hard Fescue** (*Festuca duriuscula*) is a good grass, producing a fine herbage. It fills up the spaces between the other grasses, and is found nearly everywhere. It is cheap, and consequently is rarely adulterated. Time of flowering, June; weight of seed per bushel, 22 lbs.

8. **Fine and Various-leaved Fescues** (*Festuca heterophylla*, etc.) are very much the same kinds of seeds, rather dear to buy.

9. **Sheep's Fescue** (*Festuca ovina*) is a short grass, very useful in sheep pastures, where it is much liked. It affects sandy soils most. Time of flowering, second week of June; weight of seed per bushel, 27 lbs. It is an *annual* grass.

10. **Rough-stalked Meadow Grass** (*Poa trivialis*) is a good grass for filling up turf between other grasses. It gives a fair amount of herbage of high feeding value, and is liked by most stock.

This is the most valuable of the meadow grasses. It is

distinguished from the smooth-stalked meadow grass by its rougher stalk and long pointed ligule, whilst the other has a smooth stalk and short blunt ligule. Time of flowering, June; weight of seed per bushel, 28 lbs.

11. **Smooth-stalked Meadow Grass** (*Poa pratense*) has a creeping stem, liable to take up space which might be occupied by more valuable grasses. It should not be included in permanent mixtures. Time of flowering, June; weight of seed per bushel, 30 lbs.

12. **Crested Dog's-tail** (*Cynosurus cristatus*) is most suitable for dry land and upland pastures. Herbage fine and late; it is thus not eaten off till autumn. It is comparatively innutritious, and flowers in July; weight of seed per bushel, 34 lbs.

13. **Sweet Vernal Grass** (*Anthoxanthum odoratum*) is a grass of no particular value except that it gives a sweet flavour to hay. It flowers early, about April, and continues in bloom through summer.

14. **Tall Oat-grass** (*Avena elatior*) is only of use on exposed hill-sides. It is a coarse and innutritious grass, and on other places should not be grown.

15. **Perennial Rye-grass** (*Lolium perenne*) is undoubtedly a splendid grass for temporary pastures, but its value for permanent pastures has been very much doubted by many excellent authorities, and the evidence at present is decidedly against the large percentage generally used in seed mixtures for permanent pastures. It produces a large amount of herbage, which appears early, and is very nutritious. The largest crop comes the first year, and then it gradually falls off, and by the third year its place is mostly taken by other natural grasses. The extent to which this takes place varies very much indeed. Some old pastures contain a very fair percentage of rye-grass, whilst in others it is almost absent. From an examination of twenty of the best old pastures of England, Mr. Carruthers found an average of 25 per cent. of perennial rye-grass, but the permanent pastures of Scotland contain a much smaller amount. For permanent pastures it is advisable to use some rye-grass—say 4 lbs. in a mixture of 34 lbs. Whether the rye-grass is likely to be permanent or not, it will produce plenty of grass the first year, whilst some of the other grasses will give very little. It flowers in June, and the seed weighs 28 lbs. per bushel.

16. **Italian Rye-grass** (*Lolium Italicum*) should not be sown on permanent pastures, although it yields abundant crops of hay on sewage farms. It produces a large crop the first year, and then soon dies out. It differs from the last species in its bearded spikelets. It is also more succulent, more palatable, and more

productive, and is well suited for alternate husbandry. It flowers in June, and the seed weighs about 24 lbs. per bushel.

Poor Grasses:—

Yorkshire Fog (*Holcus lanatus*) is easily distinguished by its woolly appearance. It is in flower nearly all summer. It is not generally eaten by cattle, and when eaten it is digested with great difficulty. Cattle allow it to run to seed, therefore patches of it should be mown when young.

Soft Brome Grass (*Bromus mollis*) is a very poor grass, of low feeding value. Not generally eaten by stock.

Couch Grass (*Triticum repens*) has an underground stem. Very difficult to get rid of, but is more troublesome on arable land than in pastures.

Barley Grass (*Hordeum murinum*) is objectionable because, although its leaves have good feeding properties, the seed heads have sharp awns which are dangerous to sheep and troublesome in hay.

Clovers.

White, or Dutch Clover (*Trifolium repens*) is a small clover growing close to the ground. It is more lasting than the red, although it does not show much the first year. It is very valuable for grazing pastures, and consequently its growth should be encouraged as much as possible. It is very nutritious, and relished by all stock.

Alsike Clover (*Trifolium hybridum*) is a cross between the red and the white clovers. It more nearly represents the red in growth, with several flowering branches from the same stem, whilst the flowers and leaves of the white clover spring singly from the creeping stem. The head resembles that of the Dutch clover in shape and size, but is generally of a pinker tinge. It has a large and bulky growth, with deep roots, which render it more likely to grow on otherwise clover-sick soils. It is more perennial than either the red or white clovers. It is well suited to poor land, but cattle do not like it so well as the white and red varieties.

Perennial Red Clover (*Trifolium pratense perenne*) is the cow-grass of commerce, the true cow-grass not being sold. It prefers rich adhesive loams, and yields a bulky produce.

Bird's-foot Trefoil (*Lotus corniculatus*, *major* and *minor*) grow very well on dry, sandy, or loamy soils.

Trefoil (*Medicago lupulina*) may be sown on some pastures, when it is not naturally present.

Hop Trefoil (*Trifolium procumbens*) is not to be recommended much, owing to its small dwarf habit.

TABLE OF SEEDS.

Standard Mixture.

	Lbs.	Price per lb. s.	d.	£	s.	d.
Perennial rye-grass	3 @	0	3	0	0	9
Meadow foxtail	4 ,,	0	11	0	3	8
Cocksfoot	4 ,,	0	11	0	3	8
Timothy	3 ,,	0	5	0	1	3
Meadow and tall fescue	6 ,,	0	10	0	5	0
Hard fescue	4 ,,	0	10	0	3	4
Rough-stalked meadow grass ..	3 ,,	1	3	0	3	9
Sweet vernal	½ ,,	2	6	0	1	3
Crested dog's-tail	½ ,,	1	3	0	0	7½
White Dutch clover	2 ,,	1	0	0	2	0
Alsike	2 ,,	1	0	0	2	0
Cow-grass	2 ,,	1	0	0	2	0
	34 lbs.			£1	9	3½

For upland pastures crested dog's-tail, yellow oat-grass, and sheep's and finer fescues should be added. Some people prefer to sow clovers after the grass, but that is a matter of choice.

Mixture for General Purposes.

	Lbs.
Perennial rye-grass	13
Italian rye-grass	5
Timothy	5
Cocksfoot	3
Meadow foxtail	2
Red clover	3
Cow-grass	3
White clover	2
Alsike	2
Trefoil or Lucerne	2

Per acre, 40 lbs.

Mixture for Good Medium Soils.

	Lbs.
Foxtail	10
Cocksfoot	7
Timothy	3
Meadow fescue	6
Tall fescue	3
Crested dog's-tail	2
Rough meadow grass	1½
Hard fescue	1
Sheep's fescue	1½
Yarrow	1
Cow-grass	1
Red clover	1
Alsike	1
Dutch clover	1

Per acre, 40 lbs.

After Cultivation and Manuring.

Nearly every farmer has a different way of commencing the after cultivation. The grass, when well-grown, is often fed off with sheep and lambs, taking care not to eat too bare, for the first few years. Another method is to cut the grass the first year, and then feed off lightly with young cattle after manuring with compost; or mow the grass whilst young the first year, then feeding with sheep the next year, and afterwards alternately cutting and grazing. The use of cake on the land is a good thing, but all droppings of the stock on the land should be carefully spread, otherwise there will be a growth of coarse grass around the heap of excrement. Only farmyard manure should be applied at first; the manure should be made into a compost, as cattle will feed better after compost than fresh dung. The manure should be well distributed over the land, and not allowed to remain in small heaps. It is important that the grass should not seed much during the first few years. If cut for hay the first year, the land should be manured well afterwards.

It should be remembered that a crop of one and a half tons of hay per acre removes about fifty pounds of nitrogen, fifty pounds of potash, and twelve to fourteen pounds of phosphoric acid. This amount of nitrogen, potash, and phosphoric acid can be returned by five tons of good rotten dung, or, if artificials are used, by—

3	cwts.	nitrate of soda.
1¾	,,	sulphate of potash or 3½ cwts. kainit.
1	,,	superphosphate.

But there is no occasion to supply all the materials to the soil that are carried off in the grass or hay, for various reasons:—

First, we have every year a fresh supply of plant-food, due to the gradual conversion of unavailable, insoluble matter to the soluble form, and fresh supplies of nitrogen from the nitrification of vegetable matter in the soil, and nitric acid and ammonia brought down by the rain and dews.

Added to this, there must be considered the nitrogen obtained from the atmosphere by the roots of the clover and other leguminous plants.

The question whether clovers have the power of abstracting nitrogen from the atmosphere has been debated for a very long time—Continental authorities holding that they did, and most English agriculturalists maintaining the contrary. An indisputable fact, in favour of the Continental theory, was the circumstance that, after clover had been cut and carried off the land several times, and a deal of nitrogen in this way removed, there was still found more nitrogen in the clover stubble than there was in the soil to

start with, and in spite of the fact that no nitrogen had been used as manure. Where had the excess of nitrogen come from?

Messrs. Lawes, Gilbert and Warington explained this by suggesting that the deep roots of the clover brought the nitrogen to the surface from the subsoil; but it is now undisputed that all plants of the order Leguminosæ have the power of obtaining nitrogen by their roots, and this in a very peculiar manner. If a clover plant, or any member of the Leguminosæ be carefully removed from the soil, large numbers of small nodules, or wart-like excrescences, will be found attached to the roots. With the aid of a powerful microscope it will be found that they contain small organisms that have the power of absorbing nitrogen from the air, and this nitrogen is stored up within the nodules. This can readily be proved by first growing clover in sterilized sand, watered with distilled water and dissolved salts. No small excrescences will be found, and the amount of nitrogen can all be accounted for. But if the clover is watered with an extract of clover root, or even water that has filtered through turf, the nodules soon make their appearance, and the amount of nitrogen stored up can only be accounted for by the supposition that the nodules in some way obtain it from the air.

This fact of the nitrogen-storing power of the leguminous plants explains the action of heavy dressings of nitrogenous manures on permanent pastures encouraging the growth of grasses, especially the coarser ones, at the expense of the clovers. If persisted in, the clovers will disappear. The following examples from experiments at Rothampstead will illustrate this.

	Manured heavily with Nitrogenous Manures.	Unmanured Plots.	Mixed Mineral Phosphate and Potash.
Grasses	95·91	67·43	61·03
Leguminosæ ..	·01	8·20	23·06
Other plants ..	4·08	24·37	15·91
	100·00	100·00	100·00

Every one must have observed how the clover springs up in a field where a fire has been lit and wood ashes left.

Renovating Old Pastures.

Always eat bare. Give good brush harrowings, and add seeds of those nutritious grasses which best suit the soil. Sow the seeds in autumn, harrow and roll. Manure with good compost,

twenty loads to the acre, or one hundredweight of bone meal mixed with two hundredweights of superphosphate, and two hundredweights of kainit to the acre. Basic slag is one of the cheapest kinds of phosphatic manures, and has been found very successful; from eight to fourteen hundredweights per acre may be applied. When grazing with milk cattle or growing stock, large amounts of phosphates are taken out of the soil, and must be returned in some form or other. It was because of this that the application of bones to the pasture in Cheshire was found so beneficial.

Breaking up Pastures.—It is not advisable for the farmer, when he has once got a good pasture, to break it up again. In many cases on the Chalk Downs, when this has been done, the plant-food of the soil has got exhausted through time, and extreme difficulty has been experienced when trying to lay the land down again. When breaking up, always use a skim plough, and harrow, and otherwise till the land well during summer. If necessary, *i.e.* if the vegetation does not decompose easily, the land may be limed. When first broken up, excellent crops, especially of wheat and cereals, are grown for some time afterwards, but these get into ordinary condition after several rotations.

CHAPTER VII.

LIVE STOCK.

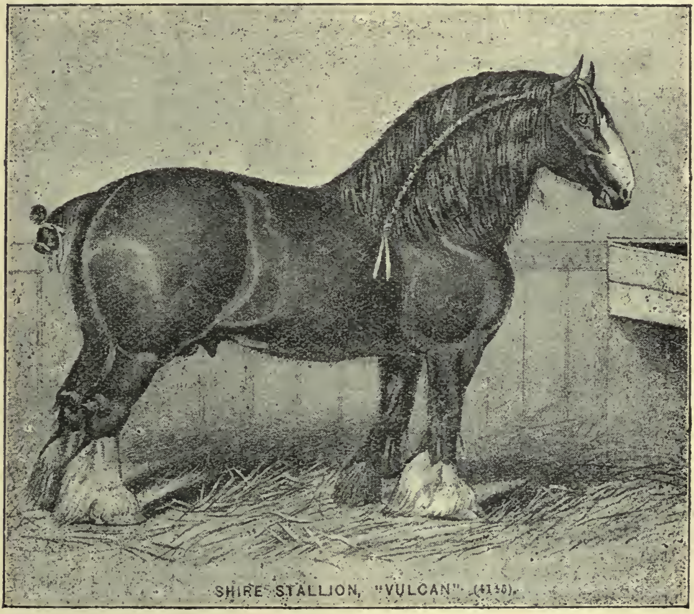
A.—*Breeds of Horses.*

THERE are many different breeds of horses, but the three most commonly used for agricultural purposes are the "Shires," "Clydesdales," and "Suffolks." The "Cleveland bays" are also used for farm work in some districts, especially in some parts of Yorkshire.

The **Shire Horses** are the largest and heaviest breed we possess; they have their origin in the old "Black Horse," and are a great improvement on the original breed. They are more suitable for heavy work, such as on railways, or heavy town waggons, than for agricultural purposes; although they are much used for the latter purposes on strong land farms in the Midlands and other districts. The farmers of the Fen counties claim to be the breeders of the largest and strongest Shires. As a breed they vary much in size. The heaviest are usually selected for heavy draught purposes, whilst the lighter ones are retained on the farms. They also vary in colour, but brown and bay may be considered the prevailing colours, whilst black, roan, and grey are common, and occasionally a chestnut may be seen. They often have white "stockings" and white markings on the face.

A good stallion should stand from sixteen and a half to seventeen hands, girth about eight feet, and measure about twelve inches below the knee. He should have a very wide chest, this being a great sign of strength and constitution. The line from the point of the shoulder to the withers should incline well back. The neck should be arched, deep and muscular, carrying a good mane; but the neck itself should not be too long. The head is usually fairly large, and should have a masculine appearance. The back short, but not low, the ribs well sprung, and should

extend well back, so that the space between the last rib and the hook bone is short. Loins strong and muscular. The quarters, from the hook bone back, should be long, with the tail well set. The thighs should be large and deep; the hocks clean and fairly large. The bones of the legs flat and strong; round bone should be avoided. The canon bone, or shank (from knee to fetlock), should be short. The pasterns should be rather short, but not too straight. There should be plenty of silky hair from the knees and hocks downward. They should have good



SHIRE STALLION, "VULCAN" (4145).

FIG. 53.

sound feet, and be free from any sign of side bone. A stallion should be active, and a perfectly free mover. Some of these stallions trot at a surprising pace; this is considered, by many breeders, a strong point.

These stallions, besides serving mares of their own breed, often leave excellent stock for farm work and light waggons, when used to serve mares of too light a stamp for such purposes. The progeny often possess much of the strength of the sire, combined with the activity of the dam, without being plain in appearance.

The **Clydesdales**, as their name would imply, are natives of Scotland. They are supposed by many authorities to have originated from a cross between the old British "Pack Horse" and some imported Dutch horses. Whether this be so or not, the Clydesdales of the day are a very excellent breed of cart-horses. They are slightly smaller than the Shires, and there are a few characteristic points in which they differ from them; although many men say there is no appreciable difference in the appearance of a good-looking Clydesdale, and a good-looking Shire. This, however, is not the usual opinion; but certainly some first-class Clydesdales are very like Shires in appearance.

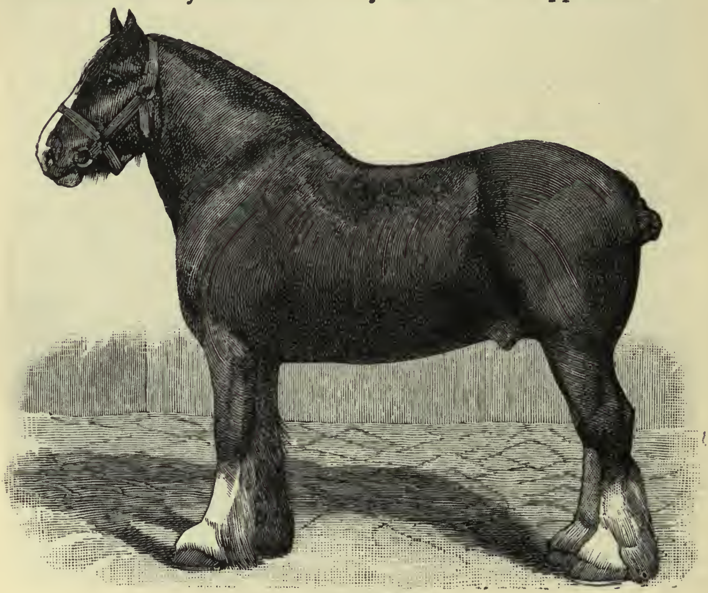


FIG. 54.—The Clydesdale.

The characteristic differences are, that the Clydesdales have finer bones, longer pasterns, and better feet, but they are smaller in girth and not so massive in the body as Shires. They are not so strong, but take longer steps, and are faster walkers; this makes them more adapted to farm work, and are usually preferred by carters who have great distances to travel.

There is usually a considerable amount of jealousy between the Shire and Clydesdale breeders. Both breeds have been selling well of late years, very long prices having been paid, in many instances, for good specimens of both these breeds

for exportation. The Americans, especially, have been good buyers.

The points of a Clydesdale may be summed up as follows:—Head not too large; neck muscular, upstanding, and rather arched; shoulders slanting; ribs well sprung; body round, with good back and loins; barrel light; strong quarters; legs rather long, with good flat bone, and plenty of hair below the knees; they should have good broad open feet. They stand as a rule from sixteen to sixteen and a half hands high; some are very much higher. They often show too much daylight between the belly and ground. Breeders of late years have paid considerable

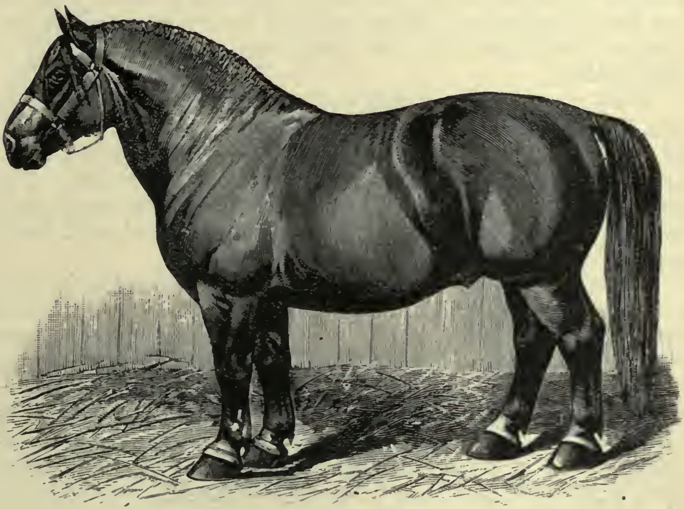


FIG. 55.—Suffolk Punch.

attention to filling out the body more, and in many cases their efforts have been attended by success.

The prevailing colours are bay and brown, and they often have white faces and "stockings;" blacks and greys are occasionally seen, and in exceptional cases chestnuts.

There is perhaps no breed of horses so well adapted to agricultural purposes as the **Suffolk Punch.** These horses have been in great demand of late years, both at home and abroad; and we have every reason to believe that the Suffolk breeders have a bright future before them. They have not only come into repute for farm purposes, but also as waggoners, especially where speed is required. They step lightly, and are consequently better

adapted to trotting with an empty lorry or waggon than other cart-horses.

Their being clean-legged gives them a great advantage over Shires or Clydesdales for farm work, especially in wet weather or on clayey soils; as the soil has no chance of adhering to their legs in such large quantities as it does with these hairy-legged animals. The unnecessary amount of work experienced by the Shire or Clydesdale in carrying this soil all day, is escaped by the less hairy Suffolk.

They are strong, active, and usually pull without gibbing; the unpleasant business of "gallop and stop" or "jerk and smash a chain," are by no means characteristic of the Suffolks. They are, as a breed, exceedingly hardy, and will keep themselves in good working condition with less food than either the Shires or Clydesdales.

They are almost invariably chestnut in colour, with manes and tails lighter than the rest of the body, but usually of two shades. They sometimes have a white star on the face, but the legs should be free from white. They are occasionally sorrel or bay. They stand from fifteen to sixteen hands high, possess good constitutions, and lay on flesh very quickly in return for extra food, after having perhaps dropped in condition.

The head should be carried well forward with a spirited appearance, on a strong arched neck. The shoulders are deep, but not set back as far as those of the Shire. This point in draught horses is sometimes held to be advantageous, on the ground that they are less likely to pull against their wind, and choke in their collar. The body is round and compact, looking perhaps a little too heavy for the short clean legs supporting it; the chest is wide, giving plenty of room between the two fore legs. They should girth well, be ribbed well back to the hook bone, and carry plenty of belly; the hind quarters are fairly long, but not usually so wide as those of the Shire.

They often look smaller than a Shire or Clydesdale of the same weight; and weight for weight will do more than either of these breeds, on the same keep. They are usually active, and possess great power of endurance.

A few white hairs may occasionally be seen on the rumps of these chestnuts, which, to a person not knowing the horse, might be suggestive of age. This point is peculiar to certain strains, and horses possessing this peculiarity are usually good ones.

These horses are sometimes low in the back; this gives them a very awkward appearance, and with their strong neck and large shoulders the fault is easily shown up.

Some complain of their bone being occasionally round, instead

of flat, and consider them more liable to go wrong in their joints than the Shires or Clydesdales. Their feet, too, are often considered a weak point. Their general appearance is excelled by both the above-mentioned breeds.

The Thoroughbred, or "Blood-horse," is the oldest established breed we have. This breed traces back to the old native English horses, which are generally supposed to have been improved by imported Turkish and Arab blood.

They are tall, slender-looking animals with a small body, covered with a thin skin, carrying a fine glossy coat. Head small,

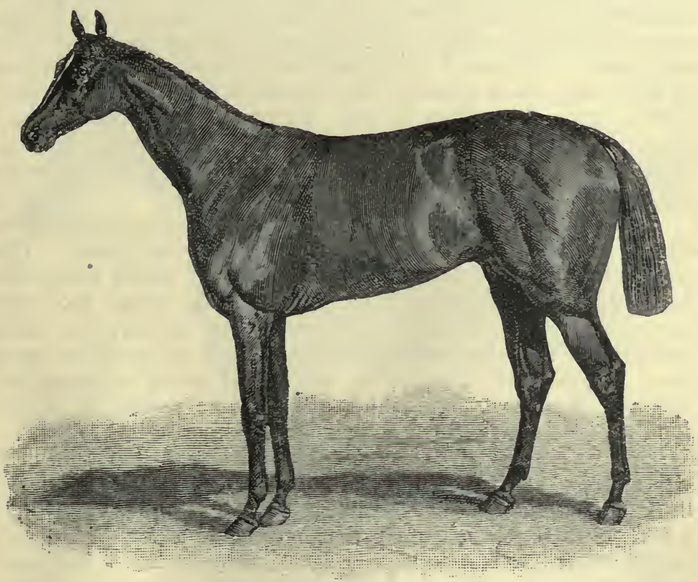


FIG. 56.—The Thoroughbred.

with a bright, prominent, intelligent-looking eye. Neck long and slender, carrying small mane. Withers high, and shoulders sloping well back. Body deeper in front than behind; often straight over the rump or croup, in this case the tail is set high. The legs are long, clean, and sinewy, free from any long hair; bone should be flat and clean. They stand from 15·2 to 16 hands high. Bay, chestnut, and brown are the prevailing colours, whilst grey may occasionally be seen.

This breed of horses excel all others as regards speed and endurance; but, owing to their high breeding, they are usually very

nervous and excitable, and therefore unfit for slow or steady work. They are used for both riding and driving.

Besides their importance in producing horses for the racecourse, the stallions are used for getting hunters, hacks, and driving horses. It is for these purposes that they are of the greatest importance to the tenant farmer. Since the premium system has been instituted, the ordinary farmer with a likely half-bred or light mare, has been able to get her covered by an excellent thoroughbred horse, without having to pay an extravagant fee. The premium for each selected horse is £200; the conditions being, that a stallion winning a premium shall serve not less than fifty half-bred mares, if required, during the season, at a fee not exceeding forty shillings, and two and sixpence groom fee, for each mare. This excellent system has, of course, induced farmers to have such mares covered, and the result is usually satisfactory. It will greatly depend on the dam as well as on the sire, to which class the foal will be eligible for classification. If it fails to be a hunter, it will in all probability sell as a hack or harness horse, or in some cases be a useful combination of both.

Some people recommend mating Shire or Clydesdale mares with a thoroughbred horse, in order to get half-bred horses. This cross often fails to produce the happy mean which brings out the good points of both. The result of such crosses too often brings disappointment, for instead of the breeder becoming possessor of the ideal animal looked forward to, he will in many cases get an awkward-looking specimen, having characteristic points of the two breeds, which on the same animal are widely opposed. A result of such a cross may be described as follows:—A horse with perfectly clean thoroughbred legs, a long thin neck with a cart-horse head, fine high withers, cart-horse body and belly, and a high straight breedy hind quarters. The above description is taken from a few specimens that have come under the author's notice, but it would only be right to mention that, in a few cases, we have known breeders have better luck, when good-looking specimens and useful animals have been produced.

There is more chance of the mare proving in foal when mated with a horse of a different breed. For instance, we have known a Shire mare continually take a Shire stallion without effect, and yet settle to the first service of a Thoroughbred. This is often a point in favour of the cross, when it is particularly desired that a mare should get a foal.

The **Hackneys**, or roadsters, are undoubtedly a very useful breed. They may vary a great deal in size and weight, the heavier as well as the lighter ones being grand movers, with plenty of style and action.

Almost any kind of horse could be got by the use of these sires, providing sufficient judgment is exercised in selecting both dam and sire, in order that the progeny may be adapted to the required purpose.

Formerly the Hackneys were chiefly bred in Norfolk and Yorkshire. The horses from the two counties were distinct in character, the old Norfolk trotter being heavier than the Yorkshire horse; but since the introduction of foreign blood in each case, these horses bred in the different counties have become much more uniform in type, and like each other.

The points desired are that they should be neither too slender nor too heavy, standing about fifteen hands two inches high, with good free action, and level appearance. The head should be neat

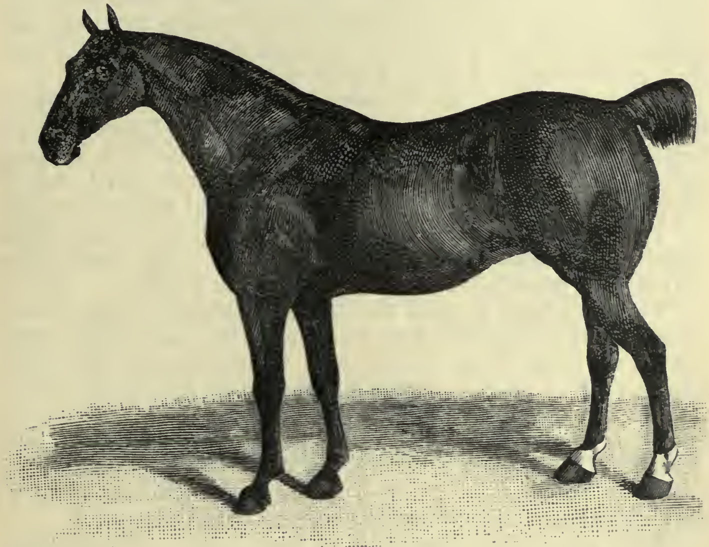


FIG. 57.—The Hackney.

with a prominent eye and good-tempered countenance; neck not too short, good withers and sloping shoulders; short back, strong loins and rump, well sprung ribs, with plenty of girth and good chest. (Narrow-chested animals are often poor stayers). They should be fairly long underneath, with fore legs not too long, and well set forward, so that the animal stands on plenty of ground. The legs should be free from blemish, with strong well-developed hocks, and good sound feet; toes should not be turned in.

No doubt the best plan for the tenant farmer, when dealing in this class of animals, is to breed for hunters, as the misfits will usually sell as ordinary saddle and harness horses, or for posting purposes.

For driving purposes it is not necessary that they should be so short in the back, or have such sloping shoulders.

Cleveland Bays, and **Yorkshire Coach-horses**, are classed together by the Royal Agricultural Society of England, though the breeders fight hard for separate classes. These two breeds are closely related, but still they differ a little in character, the Cleveland being thicker and heavier, with less action than the Yorkshire Coach-horse. In many instances the blood of these two breeds has been intermingled with great advantage to both breeds; the Cleveland blood being useful to counteract the tendency of the Yorkshire Coach-horse becoming too leggy and lightboned, whilst the Yorkshire Coach-horse imparts action and style to the Cleveland which is often wanting in this breed.

It appears that the Cleveland Bay must, at one time, have exhibited much of the type of the cart-horse, and that the breed we now possess has been acquired by selection, keeping certain lines in view. In proof of this we have recorded that, in 1847, an aged cart stallion of the Cleveland breed was commended.

The Yorkshire Coach-horse is invariably used for driving purposes. It stands sixteen to sixteen and a half hands high. Its colour is usually brown or bay, with black points.

The Cleveland is used for driving, ploughing, light carting where speed is required, and occasionally for slow saddle work. Cleveland dams, when crossed with thoroughbreds, have often been known to produce good hunters. These horses stand about sixteen hands, often a little coarse about the head, with sloping shoulders, and not too long in the back, but with long hind quarters. Their legs are clean; action not always good. Their colour is light or dark bay with black legs, mane, and tail; they sometimes have a white star on their forehead.

Both these breeds appear to be weaker in their middles than elsewhere.

Ponies are bred in various parts of the British Isles. They vary much in size, anything below fourteen hands being classed as a pony. The Shetlanders are the smallest breed, often standing very little over eight hands high; four inches being a hand. The measurement is taken over the withers from the level standing ground.

Many good ponies are bred in Devon and Wales. The Exmoors and Dartmoors are the Devon breeds, whilst those bred in Wales are known as Welsh.

These ponies are very clever and strong, with wonderful constitutions. They are much stronger proportionately than horses. Many of the Devonshire ponies are exceedingly fond of the dogs, and with a good light-weight rider will go straight with the hounds all day.

Many valuable hunters are obtained by crossing a thoroughbred or hackney stallion with a good thick Exmoor pony mare, which is able to jump and cross country, as well as having an attractive appearance.

Management of Horses.

Unless a man takes a keen interest in horses, and has had a deal of experience, he will rarely make a successful breeder. Indeed, it may be said, to become a successful breeder of horseflesh, a man should be born with that natural talent possessed by most skilful breeders. Although many such men are found in Yorkshire, Norfolk, Lincoln, Cambridge, Gloucestershire, and a few other counties, yet, speaking generally, it will pay the ordinary farmer better to turn his attention to "beef" and "mutton," rather than dabble too deeply in "horse-flesh." But, at the same time, we recommend every farmer with suitable land to breed his own horses, and, in doing so, he will occasionally have one to sell. It should be borne in mind that it will not pay a man to breed low-class horses, such as may bring £25 to £30 when three years old. This sum would scarcely pay for the food consumed in that time, if the foal had been properly fed. And, beside this, there are many items to be reckoned before a profit can be declared, such as the following: Cost of service, risk of mare not holding, risk of losing mare and foal, or one of them, inconvenience of not being able to work the dam much for some time after foaling, and cost of breaking. Most farmers possess a good useful mare, and sometimes more than one, suitable for carrying a good foal. In many cases a foal from such a mare, and got by a good sire, will grow into a horse which will be particularly adapted to the work on that farm, and will be often easier kept in condition (being bred on the same soil) than any the farmer might buy. Although such a horse might not be particularly good looking, and therefore perhaps not very saleable, it might very likely be of a greater value to the owner, than one that might fetch a much higher price in the open market.

In the case of such a horse not being required on the farm, it might be sold, or perhaps retained, and an older one disposed of, as an opportunity presented itself. The cost of keeping the dams in such cases as these would be very little, as

they would be doing their daily work almost throughout the year, whilst when breeding on a large scale the mare often leads a very idle life. In such cases sums ranging from £90 to £100 should be about the average for the three- or four-year-olds, in order to make the business pay.

Heavy horses may be broken at two and a half or three years old, and lightly worked. If not required on the farm, as soon as they become seasoned, about four or five years old, they may be sold. A horse is usually supposed to be worth most money when rising five, being at this age well seasoned and still to come in prime for work, from five to eight or nine.

In the case of slender horses the young ones may be kept for hunting, riding, or driving, until a younger one is ready to be taken up, and the other sold, at perhaps about five years old. In this way the horse is earning its own living whilst getting seasoned.

The *kind of mares to breed from* will vary with the style of horse to be produced. They should in all cases be sound animals with good constitutions, and perfectly free from vice; jibbers or mares with bad tempers should not be selected. Their bone should be sound and flat, free from any bony deposit, such as splint, spavin, ringbone, curb, etc. Round soft bone is more prone to such diseases than flat. The feet should be sound and well formed, turned-in toes should be avoided. They should be free movers with no signs of tripping or lameness. Roarers, crib-biters, or mares with any hereditary weaknesses should not be selected.

In choosing a horse, great care should be taken in selecting one that is likely to suit the mare. As a rule violent crosses should be avoided. In some cases mares with weak points are mated with horses having those points correspondingly strong, in the hope that these failings may be rectified in the progeny. If, however, the faults on either side are too glaring, the cross will usually lead to disappointment, although when less intense it will often have its desired effect.

Notwithstanding the law of heredity or "like begetting like," there is always a vast amount of uncertainty about horse-breeding, that perhaps too often favours "variation" with an additional member. Some horses cross remarkably well with cross-bred mares, others do not. Big sires often get small stock, while small compact sires may leave large well-grown horses. A good-looking sire often "throws back," and gets inferior-looking foals. There is no better way of judging the capabilities of a stallion, than by examining the stock he leaves (when possible).

The kind of soils best adapted to horse-rearing are those

which produce a good coarse pasture, affording the young animals a cheap run during summer and autumn. The subsoil should be fairly dry without being too light, whilst the soil itself should contain a good percentage of carbonate and phosphate of lime, and magnesia, in order to supply the requisite amount of mineral matter, without which the proper development of the bone cannot take place.

When a mare is inclined for the horse, she is said to be "*in season*," or "in use." When in season they are usually sluggish, often stop to urinate when working in the plough or in the harrow, rub against the next horse, or lean over on the chains, and occasionally give way to a screeching noise. They remain in season for about a week, and if not successfully mated come in use again at intervals of three weeks.

In order to test if a mare will receive the horse, she should be put to a strange one; or to the stallion that is intended to serve her, in the event of his being within easy distance: the arrangement being for the horse to be placed in a stable, loose box, or any other convenient place, with a door or gate between the two, over which the horse can get its head, but is sufficiently high to prevent the mare striking him. The mare is at first placed head to head with the horse, and then turned with her tail towards him; if she is in proper season she will stand quietly, but if not, will usually attempt to kick him.

Mares are occasionally very highly in season, but of too nervous a disposition to allow the stallion to mount. In such cases "hobbles" have to be resorted to, in order to prevent the mare kicking. This is a dangerous practice, and should only be used in exceptional cases—such as when holding up a fore leg (the usual thing to do) does not appear to be a sufficient precaution.

The "hobbles" are made of a strong rope. A loop being tied in the middle and passed fairly tightly round the neck, the two ends put between the two fore legs and around each of the hind legs, from outside in, passing behind the pasterns (between the fetlock and hoof), the ends are brought out underneath the rope running from between the fore legs back, passes outside the fore arms and under the loop around the neck, and pulled just tightly enough to prevent the mare from kicking. Great care should be exercised when a heavy horse is used; the ropes must not be drawn too tightly, as it might result in the mare not being able to bear the horse, in which case both might be injured.

A mare is more likely to hold to the horse when going out of season than at any other time. Some grooms have a pail of cold water to throw over the mare after she has been served, the idea being that the shock produced makes them surer in holding, and

more likely to prove in foal, though some condemn the practice and consider it, if anything, detrimental.

Horses travel for the purpose of serving mares during April, May, June, and July.

The period of gestation in the mare is about eleven months.

In-foal mares may be worked up to very near the time of foaling, but care should be taken to let the work be of a light character, so as to prevent any chance of straining, as it might be the cause of abortion or premature birth. In the case of a mare being accustomed to working in shafts, she should not be allowed to have any backing work to do when foaling time is approaching; in fact, they are much better doing light work in chains at this period.

They should be kept in good thriving condition by the supply of good nutritious food, as it must be remembered that the foal, as well as the mare, will require nourishment, besides a certain amount being taken up for the production of milk. Mares in foal should never get dusty hay.

Just before the period of *parturition* the mare should be kept in a good roomy box, and well watched; some one should always be present during parturition. A mare very rarely requires any assistance in foaling, but in the case of her getting a hard time, she may kill the foal by knocking its head against the wall, during parturition, or may step on it as she rises, in the event of the navel string not snapping. When an attendant is present he should cut the navel string, and tie it with a piece of disinfected waxed cord; he should also see that the mare's teats are clear, and put the young foal to suck. In some cases the foal has difficulty in expelling the fæces, which may form hard lumps in the anus; these should be cleared by a gentle syringe, or by the insertion of a tallow candle. They are sometimes born with a closed anus; in such a case they should be cut with a knife and dressed with a disinfectant.

When mares are late they are often allowed to foal in the field, but should be closely watched. April and May are the usual months for mares to foal, but some arrive earlier and some later in the season.

In the case of the mare having no milk or dying during parturition, the foal is often very difficult to rear. The best thing to give them is a little cow's milk with a small amount of sugar dissolved in it. Some people recommend a very complicated mixture, but, as a rule, the one mentioned proves the best. The young animal usually finds the want of the mother's first milk, as it acts as a purgative in getting rid of the fæces. Below is a composition of mare's milk compared with that from a cow.

Composition of Milk (Warington).

	Mare.	Cow.
Water	90·2	87·0
Casein	1·9	3·7
Fat	1·1	3·9
Sugar	6·4	4·7
Mineral matter	0·4	0·7

Management of Mare and Foal.

The mare with her foal should be kept in a loose box, where she should be supplied with plenty of good food, with an occasional bran mash. As soon as the weather is fine enough, they should be allowed to run together on the grass by day, being brought in by night at first; but, usually, by the middle of May they may be allowed to run out altogether. Late foals are sometimes never brought into the box at all.

The mare should be allowed to run with her foal for at least a month before she is put to any work. A nursing mare is usually in a weak condition, and works faintly, consequently she should only be put in light draughts. When the mare is worked whilst nursing, the foal is, as a rule, left in the loose box, where it scampers about in an excitable manner until the mother returns. Some farmers allow the foal to run by the side of the mother whilst at work.

Before the mare is returned to the foal after working, she should have a little milk taken off, as the first milk after her exertion may act injuriously on the young foal.

A male foal is named a "colt," whilst the female is known as a "filly" foal.

The usual age for weaning is about five or six months old; by this time the little animal will have learnt to eat grass and a little crushed oats or meal. If possible, a foal should not be weaned alone; it often frets without company. In the event of the breeder only having one, it would be well for him to make an arrangement with the nearest neighbour who may have one to allow them to run together, in which case they might be kept on each farm alternately.

Some people prefer to keep their foals in loose boxes during winter, giving them hay, a little crushed oats, and perhaps a little linseed cake, as well as a few roots; whilst others recommend keeping them on the pastures, with a shed to retire to when they wish, where they get a supply of hay and corn once a day. We much prefer the latter plan, for the following reasons. They get much more natural exercise, and, consequently, develop better

bone, muscle, and feet than when kept indoors. The outdoor life hardens their constitutions, and is more conducive to the development of good lungs. Foals lying out cost less to keep than those kept in boxes all the winter.

They run on grass during the summer, and get the same treatment as described throughout until they are taken up to be broken.

The colts are castrated usually at one to two years old, although some breeders have the operation performed at six to eight weeks old.

When a horse is to be retained on the farm it is often well to let him run until two years old before performing the operation. They get slightly coarse in the head, but develop thick muscular necks, and massive chests, and are usually stronger in constitution. People who object to the coarse appearance of the head and neck prefer to castrate at one year old. It is also often considered that the operation is attended by less risk at one year old than at two. The operation is usually performed in the spring. Some castrate with the animal standing; but the more usual way is to cast the horse on the grass by means of "hobbles." As soon as the horse is down it is placed on its back, and its legs are tied securely together with the ends of the hobbles. Precautions should always be taken in having strong ropes, as a powerful horse might suddenly burst them during the operation, which would be exceedingly awkward.

The operator stands behind the horse; the purse and penis are washed, and dressed with disinfecting oil. The purse is cut with a very sharp knife, one testicle taken out at a time, and the clams put on; the cord is burnt through with the searing iron, a little ointment put on and reburnt to prevent bleeding. The second stone is taken out in the same way; the parts are then dressed with a disinfectant, and a little lard is rubbed around the parts to prevent inflammation taking place after the operation.

Young farm horses are usually broken in the winter, when rising three years old, so that they may be got into working order to assist at the busy time, when preparing the ground for sowing the spring and summer crops.

In some cases, when the farmer happens to be short of horses, or has mares in foal, they may be broken to work in chains when rising two, to assist in spring work, and then allowed to run during the summer, and broken to harness in the following winter.

Horse-breaking.—A great deal depends on how a young horse is handled; a well-broken, tractable horse will usually fetch a great deal more than one, similar in all other respects, but badly trained. A young horse with a peculiar temper, placed in the

hands of a careless breaker, is often ruined for ever; whilst if it had been put in the charge of a patient and skilful trainer it might have been made fairly tractable and a valuable animal. Hence it is often economical to place a young horse under the care of an experienced hand, although it may cost a little more money.

The modes of breaking a farm horse only vary, as a rule, in minor details, differing a little according to locality and circumstances. So if we describe one common method it will be all that a student will require. Unless the animal has been handled when young, the first thing to be done is to place a long halter on its head, so that two or three men can get hold of it, to prevent its escape. When the halter is put on, a half hitch should be taken round the loop, as shown in Fig. 58, to prevent its running too tightly round the jaw.

Fig. 58.

The men get hold of the rope, whilst one stands behind with a whip to prevent its hanging backwards. They then proceed to a soft ploughed field, or a loose sea beach is still better. The animal is then "lunged." This consists of the men holding on to the halter, whilst the whip sends the animal round, describing a circle; first going a few rounds the near way (left), and then a few the further way.

The left side of a horse, as a man sits in the saddle, is known as the "near side," the right the "off," or "further" side.

This exercise on the soft ground soon puffs the animal, and makes it much easier to handle. The next thing is to get it into a loose box to put the bridle on, and place the bit in its mouth. It is a good plan to allow it to stand in the loose box with the bridle, bit, and side-reins on for a few hours every day, so as to let it get accustomed to the bit before being led out.

Some breakers use very sharp bits, which cut the sides of the jaws, and cause inflammation of the lining membrane of the mouth; this is both barbarous and unnecessary.

The animal is then usually shod on the front feet, and led out on the high way in order to get it accustomed to passing carriages, carts, etc. When led out in this way it should have the breaking-gear on, known as a dumb jockey, on to which the side reins are fixed. To get it to steer properly with the bit, it is necessary to lead it from both sides alternately.

When it answers the bit in this way, the breaker stands behind

with a long pair of reins, whilst a man on either side leads it, so as to keep the horse from turning or running backwards. As soon as it becomes under the command of the reins, the breaker takes it to the highway, to make it pass any vehicles, etc., that may be met, without being led by the side.

As soon as the animal is under command of the reins it is generally mounted and ridden; when mounted for the first time it usual for the breaker to be accompanied by another person on horseback, until the young horse gets accustomed to the saddle. In the case of a farm horse it is not ridden much; but when intended for saddle work it is broken completely, and taught to canter, etc.: it should answer the rein on either side with a delicate pull. In order to develop good action and a high step, young horses are sometimes ridden over small pebbles with magnifying glasses on.

It is usual to break a horse to chains before putting it in shafts. In order to get it accustomed to the chains rubbing against its legs, it should be taken in a field with two long chains held out by two men and allowed to rub against the legs whilst it is led by the breaker. After this has been done satisfactorily, the animal is yoked to a log, or anything that it can draw easily, so as to get it familiar with the collar. In the south of England, where two-horse carts are used, young horses are usually yoked in front of the shafts, and behind the leader, being of course led by the breaker to start with. The leader should be a good, steady, strong horse, then the young one cannot turn to the right or left, but is bound to follow. No larger load is put on the cart than the two horses can manage easily until the young animal gets accustomed to the collar, when it may be made to pull a share. It is a great mistake to overload to begin with, for if a young horse finds that it has got more than it can easily manage it will often show ill temper, and, consequently, turn a jibber. Many a young draught-horse has been spoilt by being overloaded before it has been properly seasoned, or by being worked with jibbing horses.

The next operation after working in front of the cart is to put it with another steady horse in low draught. A chain harrow is a good implement to start with, as there is no chance of the horse damaging itself by coming back on it, whereas there might be a risk in using an ordinary harrow. It should be tied back to the other horse's collar, to prevent it getting too far in advance. As soon as it gets to work well in the chain harrow it may be put in the plough, and is usually placed on the land side. If it is at all inclined to kick whilst coming round at the headlands, the plough is the best implement for preventing it, as, by pressing on the stilts, the whipples and chains can be kept higher than in any other low

draught. There is, consequently, less chance of the chain rubbing against the bottom of the legs, or of the animal getting a leg out of trace, which, with young horses, is often a cause of kicking.

An advantage-whipple should be used when a young horse is first yoked, so that it may get less than half the draught.

Young horse.

FIG. 59.

After the animal has become thoroughly familiar with chain-work, it is usually easy to break it to the harness. The best thing for this purpose is to get an arrangement where the shafts are fixed on to the axle-case, and a seat put in the place of the butt of the cart—the heavier and stronger it is the better. As soon as the animal is tackled to the shafts, a heavy log of wood should be fastened to the axle-case; this should project backwards and downwards, so that if the horse attempts to rear, this comes in contact with the ground and prevents it. If the shafts, axle, and wheels cannot be procured without the butt, an ordinary cart will answer the purpose.

A strong rope should be passed over the rump of the horse and tied to each shaft to prevent its kicking; this is named the "kicking-strap."

The animal should be led by a man on each side until it goes safely with a man driving, it may then be worked in the cart in the ordinary way.

If required for a carriage or posting purposes, it will need to be driven a great deal in a light conveyance until it will pass everything on the road without being shy or nervous; such things as traction engines will try their boldness as well as anything. A horse that is broken for driving should almost guide with a thread, and answer the rein as well on one side as the other. It should be driven through town streets and got accustomed to a railway station before leaving the breaker's hands.

The cost of keeping a farm horse will vary in different districts. Where very large horses are kept, the working days long, and the farmer fond of seeing his horses carrying plenty of flesh, they eat far more than when circumstances are somewhat opposite. The farm horses in the north of England are, on the whole, larger, work longer hours, and are often better cared for than in some of the southern counties, consequently they get a more liberal ration.

Farm horses are, as a rule, brought to the stable on dry food

in October, and will generally remain until May. They are turned out earlier in some districts than others; but, on an average, they are in the stable about thirty-two, and on grass twenty weeks.

Farm horses usually live on oats, hay, straw, and roots. Many farmers give a small quantity of beans with the crushed oats, and a bran mash on Saturday nights.

They usually get straw for the first twelve weeks, whilst it is fresh, then a little hay with the straw for the next four, and the last fourteen hay, with perhaps a little straw at nights. Some liberal feeders give hay altogether.

The Cumberland horses are chiefly Clydesdales, and receive from a stone to a stone and a half of oats daily, whilst in some parts of the south of England, where the horses are smaller, from twelve to fifteen pounds of oats per day is considered liberal, getting twelve when in ordinary work, and fifteen when the work gets harder, as in spring. The horses in the South of England usually get mangolds, whilst in the north a few swedes are more common. From sixteen to twenty-four pounds per day of hay or straw may be taken as the quantity consumed, varying with the amount of corn given.

Estimated Cost of Keeping a Cumberland Farm Horse from October to middle of May, 32 Weeks.

First Period: 12 *weeks.*

		s.	d.
16 lbs. straw per day = 1 cwt. per week, at 1*s.* 6*d.*	..	1	6
17 ,, oats ,, = 3 bus. ,, ,, 2*s.* 3*d.*	..	6	9
16 ,, swedes ,, = 1 cwt. ,, ,, 0*s.* 6*d.*	..	0	6
Straw for litter = $\frac{1}{3}$ cwt. ,, ,, 1*s.* 6*d.*	..	0	6
Twelve weeks at ..	..	9	3

Second Period: 4 *weeks.*

		s.	d.
8 lbs. hay per day = $\frac{1}{2}$ cwt. per week, at 3*s.* 0*d.*	..	1	6
8 ,, straw ,, = $\frac{1}{2}$ cwt. ,, ,, 1*s.* 6*d.*	..	0	9
17 ,, oats ,, = 3 bus. ,, ,, 2*s.* 3*d.*	..	6	9
16 ,, swedes ,, = 1 cwt. ,, ,, 0*s.* 6*d.*	..	0	6
Straw for litter = $\frac{1}{3}$ cwt. ,, ,, 1*s.* 6*d.*	..	0	6
Four weeks at ..	..	10	0

Third Period: 16 *weeks.*

		s.	d.
16 lbs. hay per day = 1 cwt. per week, at 3*s.* 0*d.*	..	3	0
17 ,, oats ,, = 3 bus. ,, ,, 2*s.* 3*d.*	..	6	9
16 ,, swedes ,, = 1 cwt. ,, ,, 0*s.* 6*d.*	..	0	6
Straw for litter = $\frac{1}{3}$ cwt. ,, ,, 1*s.* 6*d.*	..	0	6
Sixteen weeks at ..	..	10	9

Cost of Winter Keep.

	£	s.	d.
12 weeks, at 9*s*. 3*d*.	5	11	0
4 ,, 10*s*. 0*d*.	2	0	0
16 ,, 10*s*. 9*d*.	8	12	0
	£16	3	0

Average weekly cost about 10*s*.

Cost of Summer Feeding.

First Period: 6 weeks—busy work.

	s.	d.
Grazing per week	3	6
Oats 1 bus. per week	2	6
Cut fodder for six days 1½ cwt., at 8*d*.	1	0
Six weeks at	7	0

Second Period: 7 weeks—light work.

	s.	d.
Grazing only, at 4*s*. per week	4	0
Seven weeks at	4	0

Third Period: 7 weeks—busy work.

	s.	d.
Grazing, corn, etc., per week	7	0
Seven weeks at	7	0

Total Cost of Summer Keep.

	£	s.	d.
6 weeks, at 7*s*. per week	2	2	0
7 ,, 4*s*. ,, ...	1	8	0
7 ,, 7*s*. ,, ...	2	9	0
	£5	19	0

Average cost per week in summer, 6*s*.

Total Cost of Food the Year.

	£	s.	d.
Total summer keep	5	19	0
,, winter ,, ...	16	3	0
	£22	2	0

Average weekly cost per year about 8*s*. 6*d*.

The horse would probably leave about six tons of manure, worth 3*s*. 6*d*. per ton. This would reduce the total keep to about £21 for the year.

It should be clearly understood that the ration given is a typical one of this neighbourhood. As different farmers have different ways of keeping their horses, it would be almost

impossible to give rations to be in accordance with those given in different districts. Many farmers would consider this ration liberal, but others might think it low. Farm horses in the southern counties cost less than this, and, as a rule, do less work than the Cumberland horses.

Beans might be added to the ration by reducing the oats, without making any difference to the cost.

Some of the hay and straw might be chopped and mixed with the corn for dinner times. As horses have only a limited time for dinner they can consume more of the chop than when given in the long state.

The price, 2*s.* 3*d.* per bushel, is below the present market value for white oats weighing forty-two pounds per bushel: but still it is a good average price, and it must be taken into consideration that the oats horses consume are not so well conditioned as those sent to the market. Nothing is charged for crushing, as that would balance the cost of marketing if sold. The price is raised to 2*s.* 6*d.* in the summer, owing to oats being then usually dearer than in winter.

The hay, straw, and roots are charged lower than usual market prices; but as the farmer is generally bound by agreement to consume such produce on the farm, only such prices as cattle would be likely to return for their consumption can be charged.

The amount of litter, to some readers, might appear low; but if all the clean straw be shaken back, and about five pounds added daily, it will usually be found sufficient.

In some cases carrots are added to a horse's ration; they are much relished by them, and should be given if a horse is not quite well, or off its feed. It should be remembered that they tend to make the ration more costly if given in large quantities.

The Blacksmith usually charges from 2*s.* 6*d.* to 3*s.* 6*d.* per set, and from 1*s.* 3*d.* to 2*s.* for removing the shoes of farmers' horses. They require to be shod oftener on some farms than others, sharp stony soils wear the shoes fastest. In the ordinary way, farm horses should get from three to four new sets during the year, and the shoes should be removed the same number of times. Besides this, they will require to be frosted or sharpened during frosty weather. Some farmers contract with the smith to shoe their horses for a stated sum, 15*s.* per horse being about a fair average price paid under this system. Other smith work, such as repairing implements, carts, laying and sharpening harrows and cultivators, new tyres for cart wheels, repairing chains, etc., are expenses which indirectly belong to the horse. When speaking of the cost of a man and pair of horses per day, the carts and implements used by the horses are usually included; but

some people might prefer to charge this item of repairs separately against the crops. Taking one year with another, these items would amount to from 25*s.* to 30*s.* for each horse per year.

The Saddler's bill for repairing harness, restuffing collars, repadding harness pads, and yearly depreciation of harness could not be reckoned less than 13*s.* per horse per year.

Depreciation and Risk.—After a few years' work the value of a horse decreases yearly, and finally it has to be replaced by a younger one. The amount the horse has fallen in value, divided by the number of years it has worked on the farm, will give its annual depreciation, which item has to be added to the yearly cost. In working out an example to explain this, we know quite well that farm horses differ very much in value, but we will consider £38 to be the average value of a four-year-old farm horse. Suppose this horse to work well for ten years; it would be fourteen years old, and might sell then for about £16. It is plain that the horse has depreciated £22 in value in ten years, which would amount to £2 4*s.* per year.

Besides this item there is a risk of losing the horse, or its getting lame or blemished in any way, which would lessen its value more or less under different circumstances.

Horses sometimes require veterinary attendance, which on a farm is usually very little, but still it must be taken into consideration, as some years it might amount to a large sum. To arrive at these items suppose that we are dealing with a stable of six horses, varying in value from £16 to £38, then the average value would be £27. If one of these horses died every six years there would be a loss of £27 = £4 10*s.* a year to be divided amongst the six horses, = 15*s.* per year. To this, 5*s.* might be added per horse to cover the veterinary expenses, and also any depreciation that might occur in the value of the horse from being lamed, blemished, etc. The three items combined making £1 per year.

Then there will always be some little repairs to be done in the stable, besides new rugs, brushes, combs, etc., to be supplied at intervals. We will reckon this item to amount to 30*s.* per year in a six-horse stable: that would equal 5*s.* per horse.

If any allowance is to be made for attendance and grooming, not less than £1 10*s.* could be charged. Some would object to this charge, as it would be included in the man's wages, when speaking of a man and team, and, therefore, this item might be reckoned twice over if not careful.

Interest of five per cent. on £38 on the first cost of the horse = £1 18*s.* for the year.

Total cost of keeping the horse for one year—

	£ s. d.	£ s. d.
For food consumed	22 0 6	
Deduct value of manure	1 0 6	
		21 0 0
For shoeing		0 15 0
,, other smith's work connected with the horse ..		(?) 1 5 0
,, saddler's bill		0 13 0
,, yearly depreciation		2 4 0
,, vet. and risk		1 0 0
,, repairs to stable, etc.		0 5 0
,, attendance .. .. (?) £1 10 0		
,, interest on capital, 5 per cent. on £38		1 18 0
		£29 0 0

Some farmers, who sell their young horses at five or six years old, would probably object to the item for depreciation, as their young horses would increase in value from three to six years old. It should, however, be remembered that when young horses are intended for sale, they not only cost more to keep, but it takes three unseasoned horses to do the work of two seasoned ones, as when they are worked too hard it injures their appearance, and consequently depreciates their value.

Management of Horses and Stables.

Horses, like all other farm animals, should be fed regularly, and should get their first feed, which might consist of corn, hay, or chop, with perhaps a few roots, very early in the morning, usually about five o'clock.

The stable should be cleaned out every morning. If the bedding is allowed to lie in the stall through the day, the floor has no chance of getting aired and dried as it should do. All straw that is fairly dry should be shaken back, and only the damp thrown out with the dung. The straw that is shaken back is often put under the horse's manger until needed again at night, but we much prefer to see it put in an empty stall, or at the back of the stable until required; when placed under the manger the pungent smell that rises must tend to contaminate the horse's food.

Horses should be groomed twice a day, once in the morning before going out to work, and again at night. The use of grooming is to keep the coat and skin clean, and free from mange and lice; it also gives the coat a glossy appearance. When a horse is working, it naturally perspires, and in some cases the coat as well as the sweat glands get clogged after it; this, if not removed, must materially interfere with the health of the animal. When a horse has its coat clogged in this way, a curry-comb may be

used previous to the brush. It may here be remarked, that some horsemen are far too fond of using the curry-comb. Its use should be limited to such cases as for the purpose of removing clotted dirt, or combing out clotted hair. Two brushes should be used, the first a stiff, and the second a soft, one, to give the coat a soft and glossy appearance. In some cases indiarubber brushes or pieces of flannel are used after the brushes, to give an extra shine.

A raw egg broken and mixed with the corn will produce a glossy coat, and is also good for the animal; but drugs should not be used for this purpose.

Horses should not be allowed to drink after a meal. It is a common practice amongst farm labourers to allow their horses to do this the first thing after they have had their morning feed, before going to work; this is a bad practice. The water a horse drinks goes straight to its cæcum, and consequently, when it drinks immediately after a feed, the water passes through the stomach and takes with it more or less of the undigested food. This sometimes acts as an irritant on the intestines, and may produce colic. Even though no derangement takes place there must be a loss occasioned by the food being washed through the intestines in a partially digested state.

The next point of importance is the bed. It is usual to give farm horses their bed when they come in from work in the evening, but it should be shaken up again to make it even and comfortable for them at about 8.30 p.m. The bed usually consists of wheat or oat straw. But, when this is scarce, peat moss will be found economical; it makes a comfortable bed, and acts as a disinfectant, having a great power of absorbing both gases and liquids. It is for this reason more valuable as manure than straw. As soon as it gets damp it should, of course, be removed. It is particularly adapted for use in loose boxes, and should be thrown up against the sides of the walls by day and replaced at night, when horses remain in the boxes idle.

The Stable.—A good farm stable should be about twenty feet wide; this leaves a distance of about eleven feet behind the horse. The stalls should be about six feet wide, and the partitions higher in front than behind, in order to prevent the horse getting its head over to annoy or bite the next whilst feeding. The lower part of the partition between the stalls is usually fitted with wood, but the top part is sometimes made of iron grating or rails, which are placed closely enough to prevent the horse from getting its head through, but sufficiently wide to allow the horses to see one another, for the sake of companionship.

Each stall is fitted with a hay-rack and a manger. The manger should be made fairly deep, otherwise, when a horse has

a feed of corn and chaff mixed, it may be wasted to a certain extent by the horse pulling or blowing it over the side. The mangers are wider at the top than bottom. In ordinary farm stables they are generally made of wood, and are consequently made with square corners ; these are more difficult to keep clean than those with rounded bottoms and corners, which are usually found in the better class of stables, where the mangers are made of iron or glazed earthenware.

In some stables the manger runs the whole length of the stall, in such a case the hay-rack is placed above. In others, it is only allowed to come half way, and the hay is placed in a crib or heck on the remaining half. The latter is usually considered the best arrangement, as the horse is in an unnatural position when feeding from the hay-rack above the manger. The bottom of the hay-rack should not quite reach the ground; a sliding grating (from top to bottom) should be fixed within the rack to prevent the horse pulling out the hay too quickly, and wasting it. As the hay gets consumed this grating gradually falls with it. It may be lifted out when placing fresh hay in the rack.

Stables are often fitted with lofts overhead, for the purpose of holding hay. There is usually a hole over each horse's rack through which the hay is put into the rack. This system, although convenient, is not altogether to be recommended, as the odours rise from the stable and consequently injure the flavour of the hay. Another drawback is, that the racks are often filled with more than the horse will eat at one meal; whatever is left after the animal has been breathing over it becomes distasteful, and often results in more or less being wasted. It is best only to supply the animal, as near as possible, with as much as it will require for one meal; less will be wasted in this way than when more is given.

The Night Collar.—There should be a ring fixed to the manger through which the collar-strap, chain, or rope passes for fastening the horse. The strap, rope, or chain is fastened at one end to the head collar, and passed through a fairly heavy block at the other. The end with the block on it passes down an iron gutter placed in an upright position against the wall under the manger. The block is just made heavy enough to keep the strap down the gutter, whilst a very gentle pull from the horse's head will lift it when required, but directly the horse slackens its hold it returns again to the gutter ; thus no slack can possibly dangle about the horse's legs or feet. Chains are often used for fastening horses in farm stables, but they are objectionable, as they make such a noise every time a horse moves its head, consequently leather straps or ropes are often used in preference. Accidents often happen from the halter or rope of the neck collar being tied to

the manger ring. This is a very dangerous practice, as when the rope gets slack the horse can easily put its fore leg over it; consequently as soon as the horse raises its head it finds itself entangled, and has to stay in this position until visited by the stableman. If it happens to be a spirited horse it may injure itself, or pull down the manger before the stableman appears, especially when such an accident happens at night.

Some horses have a particular fancy for getting loose in the stable; this is a great nuisance, as they may kick or get kicked by other horses. They usually free themselves by rubbing the night collar over their heads. The best preventative is to use a neck collar, which should be put sufficiently tightly round the neck to prevent its being rubbed over the head. The chief objection to the neck collar is that it slightly interferes with the mane, but still they are much used in farm stables, and are much lighter than ordinary head collars. In some stables a long iron rod is run into the travis, which may be pulled out at night, when it extends from the heel post to a socket in the back wall, about four feet from the ground; so, if a horse happens to get loose, it has no chance of mixing with the other horses.

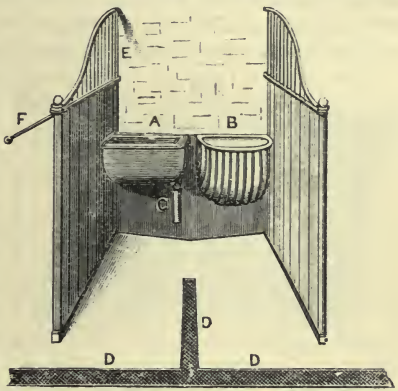


FIG. 60.—Sketch of a single stall with fittings: A, manger; B, heck or hayrack; C, gutter for night-collar strap and block; D D D, grating over drain; E, iron work (bars) at top of stall; F, rod of iron partly pulled out.

There should be a gutter or drain behind the stables, to carry off the urine unabsorbed by the litter. It should have a gentle fall towards the end of the stable at which it is to be discharged.

The stalls themselves should slope slightly towards the gutter, but the fall should be as gentle as possible, just enough to carry the liquid to the gutter. When made too steep it is bad for the horses standing in the stall, as the fore feet are on higher ground than the hind.

A well-arranged stable may be seen at Lynehow, Cumberland, the property of Major Irwin. The back of the stall is on the same level as the front, but the back half of the floor slopes from each side to the middle with a very gentle slope; an iron grating extends about halfway up the middle of the stall, through which

the urine passes to the gutter below, which is built with the necessary fall. An iron grating extends the whole length of the stable behind the stalls, over the main drain, in the same way.

A new stable should be built higher than the ground outside, in order to keep it dry. It should also be well drained, both underneath and around it. Damp stables are very injurious to the health of horses kept in them, and are frequently the cause of colds, influenza, and other complaints.

Particular care should be taken in providing ventilation. A common and fairly good way of ventilating is by means of bricks, which are placed in the wall, near the ground and in front of the horse. These bricks are not exactly allowed to meet, but still the space between them is not sufficient to cause a draught; by this means the animal is always supplied with fresh air. The heated and impure air rises to the top, and should pass out by means of ventilators.

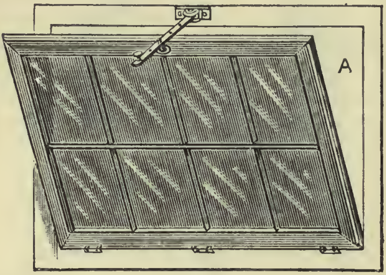


FIG. 61.

Stables should always be kept well lighted; darkness is injurious to horses' sight. The windows should be strongly constructed to prevent breakages. They may be of different construction, but we much prefer those that are hinged at the bottom and open inwards from the top, somewhat like the rough sketch above.

The width of opening the window may be regulated by means of a rope and pulley, or by means of a piece of iron coming over the top with catches, or holes and pins.

Windows constructed in this way serve a double purpose, as they may be used both as windows and ventilators. Any air that enters is directed towards the ceiling before it falls, consequently it causes no draught over the horse's back. The sides, A, may be fitted with a sheeting of zinc, to prevent any air coming in at the sides.

Low stables are very objectionable, as they so soon become full of impure air. Some badly constructed stables are so low that the horse can knock its head against the ceiling. Such stables are dangerous with young horses, as they may often knock the top of their head, and might in some cases be the cause of "Poll Evil."

The stable door should neither be too low nor too narrow;

when low, young horses are often shy at entering, or may knock their heads in doing so. When too narrow they may smash off a piece of either hook bone when entering quickly: although this might not much interfere with its working qualities, it would very much lessen the sale value.

There should always be a "loose box" on a farm. This is often a part of the stable, but for many purposes it is better separate. When in the stable with other horses it is impossible to keep the air so pure as when it is separate. It is often necessary to remove a horse from its stable companions when it gets anything wrong with it, and in such cases it should be placed in as pure air as possible. Besides invalids, mares with foals, young horses, and hacks are usually kept in "loose boxes." The usual dimensions of these boxes vary between twelve feet by ten, and fourteen feet by twelve.

Well-built stables are usually paved with tiles, specially made for that purpose, but ordinary bricks placed on their sides make an excellent floor. Cobble paving is disliked by stablemen, because it is rather difficult to keep clean. Notwithstanding this drawback, it must be recognized that it is an exceedingly healthy kind of floor; cobbles do not absorb moisture, and the spaces between them allow of the free passage of air, and therefore make a dry and healthy floor. Flags are often used and recommended for paving stables; the one point in their favour is, that they may very easily be kept clean; they are, however, very unhealthy, as they absorb moisture, and therefore should not be used.

B.—*Breeds of Cattle.*

Amongst the numerous breeds of cattle the **Shorthorn** is the most popular and most widely distributed. They are found in every county in England, as well as in many parts of Scotland, Ireland, and Wales, besides being widely distributed abroad. No other breed has yet been found to adapt itself to so many variations of soil and climate as the Shorthorn. And, although many other breeds may be more esteemed in localities in which they have been bred for generations, and therefore become acclimatized, yet it is a common thing to find the Shorthorn monopolizing the better land of these particular localities. Or, perhaps, if the breed is not kept entirely, Shorthorn bulls may be used to improve the size, and give the future generations greater aptitude to come earlier to maturity.

The great improvement of the original large, coarse, and rather awkward breed of Durham and Yorkshire was first taken in hand by two brothers, Charles and Robert Colling. For the

purpose of reducing the size, and producing cattle of a more uniform character, they purchased the famous and world-renowned "Hubbock," calved in 1777.

Lord Althorp purchased some of Mr. Robert Colling's stock at his sale at Barmpton in 1818, and started a Shorthorn herd at Wiseton. This herd was bequeathed to the steward, Mr. Hall. Most of them were sold at Wiseton in 1846, the year after Lord Althorp's death. Two years later Mr. Hall himself died, and the remainder of this herd were sold in 1848.

The celebrated Mr. Thomas Bates, of Kirklevington, made his name famous as a Shorthorn breeder early in the century. He went in for line breeding, and with his excellent bull, "Duke of Northumberland," took the first prize in the two-year-old class at the first of the Royal Agricultural Society's shows, held at Oxford in 1839. He also won prizes with two females of the same family, as well as the first prize for "Oxford Premium Cow," which left the "Oxford" name to her half-sister's lineal descendants.

Mr. Bates also owned the leading winners at Cambridge the following year. But at Liverpool, in 1841, Mr. John Booth, of Killerby, proved and continued to be a powerful rival. Mr. Bates died in 1849, and the herd was sold by public auction in 1850. Lineal descendants of this herd are still to be found carrying off prizes in our show-yards. The Bates cattle are usually smaller boned and generally considered weaker in constitution than the Booths; but they have inherited greater milking properties.

Mr. John Booth, of Killerby, and his brother, Mr. Richard Booth, of Warlaby, were both successful breeders and exhibitors. At the death of Mr. Richard Booth, in 1864, the Warlaby herd came into the hands of his nephew, Mr. T. C. Booth; whilst his brother, Mr. J. B. Booth, also a nephew of Mr. John Booth, had become the happy possessor of the Killerby herd. After his death the Killerby herd was dispersed, whilst the Warlaby herd is still in existence.

The herds that sprung up from these two lines of cattle (Booth and Bates) would be too numerous to mention; some breeders having shown preference for one line, and some the other, whilst many have met with great success by using blood of both strains in the same herd. Up to within the last ten years, the Booth and Bates breeds were the leading strains of Shorthorn blood. Unfortunately, through breeding too much for pedigree and appearance, they lost many of their good points as farmers' cattle, and fell somewhat into disrepute. At this time, the cattle bred by Mr. Amos Cruickshank, of Sittyton, in Scotland, were brought prominently forward, and animals of this strain have

lately been securing almost all the prizes at the leading shows. Although breeding from pedigree animals, Mr. Cruickshank aimed

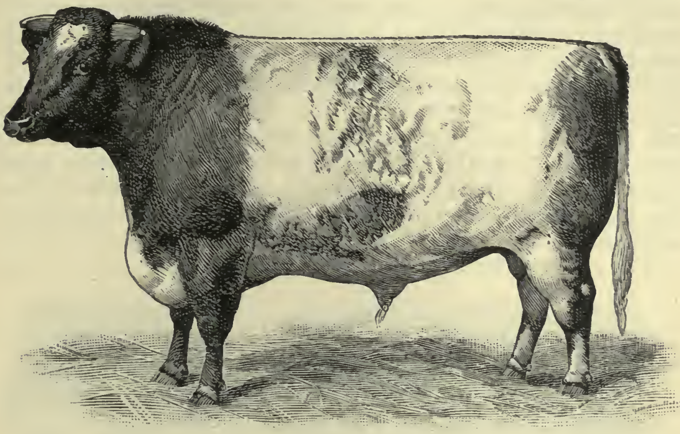


FIG. 62.—Shorthorn Bull.

at getting beasts possessing good constitutions, and which would die full of lean, marketable flesh, and in this he has certainly succeeded.

The bull's head is short, but, at the same time, fine; very

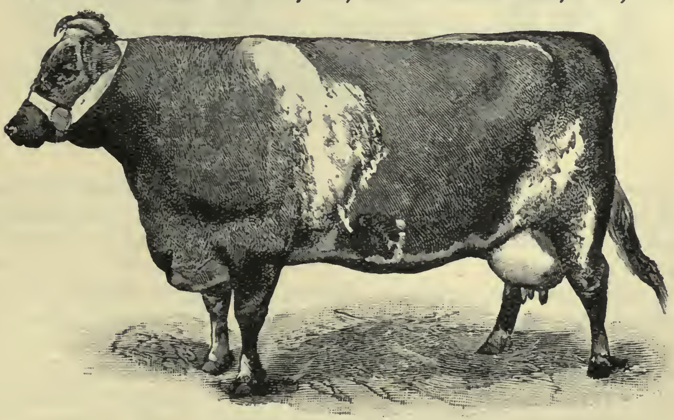


FIG. 63.—Shorthorn Dairy Cow.

broad across the eyes, but gradually tapering to the nose, the nostrils being full and prominent. The nose should be of a rich

flesh colour, free from black; eyes bright and placid; ears fairly large and thin. The head is well set on to a rather lengthy, broad, muscular neck. The horns are usually dirty white colour, curved, but rather flattened at the sides. The chest should be wide between the two fore legs, deep, and well set forward. The shoulders fine and obliquely set, the fore legs short with the upper arm large and powerful. The ribs well sprung, and ribbed well back to the hips; the barrel round and deep; the back wide, level, and straight from the withers to the setting of the tail; whilst the hind quarters should be long and well filled in. The hair is fairly long and silky; hide not too thin, with a fine mellow touch.

The colours vary very much. Light and dark roans and dark

FIG. 64.—Shorthorn Cow.

reds are very fashionable. Whites are very common, but considered delicate. Red and white is the most unfashionable colour, and consequently these cattle are not very saleable for breeding purposes.

The cow has a longer, thinner, and more tapering head; thinner and less muscular neck, and shoulders more inclined to narrow towards the chine than the bull.

The Shorthorn breed make excellent dairy cows, as well as being grand beef producers. They may be brought very early to maturity, and are suitable for grazing as well as stall feeding; but, owing to their great size, they are more suitable for strong, rich soils than poor pastures.

The **Herefords** are the prevailing breed in their own county.

They are also found in considerable numbers in the grazing districts of South Wales and in all southern counties—especially Shropshire, Warwick, Worcester, Gloucester, Somerset, Wilts,—and a few herds have been established in Cornwall and Dorset. Many of these cattle have been exported to Canada, the States, and Australia, the foreigners having often paid large sums for good specimens.

The usual colour is a rich light or dark red, with white face, throat, and chest. The under part of the body, feet, and tip of the tail, as well as the top of the neck and back, are also white.

Early in the century the colour was not nearly so uniform. Dark and light greys were common, whilst the spotted or mottled-

FIG. 65.—Hereford Heifer.

faced Herefords, having red marks intermixed with the parts usually white, are still to be seen. As late as 1862 the mottled-faced bull "Maximum," from the royal herd at Windsor, took the first prize in his class at Battersea.

The head is, if anything, small in comparison with the size of the body; the muzzle is flesh-coloured; the horns are usually yellowish with blackish tips. In the bull they spring out straightly from a broad forehead. Those of the cow extend outward and slightly upwards. As the cows get to mature age the tips of the horns become sharp, and often have to be fitted with brass tops to prevent them from ripping each other. The countenance is open, the eye full and lively. The chest is full, deep, wide, and comes well forward; whilst, as regards their

shoulders, they stand pre-eminent. The ribs should be well sprung and body deep. The back and loins are broad, the hips are moderately wide, and the hind quarter from the hip back fairly long—this breed is usually lighter at the hind quarters than elsewhere. The legs are short and small. The hair is usually wavy, soft, and moderately long, having a tendency to curl. The body should be evenly covered with flesh, which has a soft and mellow touch.

The breed is not as a rule adapted to dairy purposes, although Herefords in some exceptional cases prove excellent dairy cows; and, no doubt, with good management, combined with careful selection, they might be developed into useful dairy cows. They are, at present, more adapted for grazing purposes than anything else. Their beef is good in quality; but these beasts are often slack in their hind quarters, and also lay on a greater proportion of outside to inside fat. Like the shorthorn, they have a remarkable aptitude to fatten early; but, at the same time, the meat from the early fattened beast is usually wanting in that beautiful marbled appearance so common in the more matured Hereford.

The Herefords are often used for crossing with other breeds; but the crossing is not usually attended with such satisfactory results as when the shorthorn is used for the same purpose.

The **Devons** are divided into two breeds—North Devons, or "Rubies;" South Devons, "South Hams," or "Hammers."

The **North Devons** are the older breed, being smaller but much more symmetrical than the "South Hams." They are undoubtedly a very ancient breed; their blood has been kept remarkably pure, and consequently some very close breeding has taken place amongst the Devon herds, with the result of producing excellent symmetry without improving the size. Although this is true with the North Devons, the opposite may be said of the cattle of Somerset and South Devon. The blood of these cattle has not been kept so strictly pure; consequently they are usually much larger, less symmetrical, and better milkers, although their beef-producing qualities fall below the standard of the North Devons.

The colour of the North Devon is bright red, varying slightly in shade, some being a little lighter than others. They should have no white markings, except at the udder of the cow or scrotum of the bull. They have fine heads with gracefully curved horns of a yellowish colour, and blackish at the tips. The eyes are full and bright; ears of moderate size and yellowish inside; muzzles light flesh-coloured, with expanded nostrils; the neck rather long; shoulders usually very oblique, and well filled with flesh behind; the legs are small and straight; the chest is wide

and fairly prominent; good backs and loins with well-sprung ribs; rumps level, and should be well filled with flesh. The thighs of the cow are usually lighter than those of the ox.

In breeding, more attention is usually paid to the fore than the hind quarters. The excellent fore quarters is a strong point with the Devon; and some breeders, in trying to bring the hind parts to an equal state of perfection, have done so at the expense of the fore quarters, which they have found difficult to remedy.

These cattle, in a lean condition, usually have curly coats; but when fat they become beautifully sleek, short, and often spotted or dappled.

A fat Devon ox is a perfect-looking animal, having a very round appearance, with bones thoroughly well covered and flesh

FIG. 66.—Devon Bull.

of excellent quality. Its legs look very small and fine in comparison with the heavy body. The breed is much liked by the butcher, as it carries such a large proportion of its weight in parts where the joints are most valuable, having proportionately very little coarse flesh.

These cattle have good constitutions, and, not being too large, are suitable for grazing the hilly pastures of North Devon. They are often left on the pastures the whole year round, with perhaps a shed to retire to by night, where they may be supplied with a little straw or hay. They are small consumers; but many people complain of the time they take to come to maturity. They certainly are not so suitable for selling at an early age as Shorthorns and some other breeds; but in this respect they

have been much improved of late years. They will live on pastures which are not good enough for Shorthorns, and on such land will prove far better rent-payers. Four Devons may easily be kept on the same quantity of food as three Shorthorns.

The Devons are perhaps better adapted for grazing than for arable land, but do well on both.

The old practice of working the oxen of this, as well as the Sussex and Hereford, breeds, may be said to be almost extinct in this country.

South Devons, or "South Hams," are found in Mid and South Devon, as well as in some parts of Cornwall. Their exact origin is a little uncertain, but the generally accepted theory is that they have sprung from crossing Guernseys with Devon bulls. It is

FIG. 67.—North Devon Cow.

usual, both in Devon and Cornwall, to keep either a Jersey or Guernsey or two amongst the milking herd, in order to give the cream and butter a good colour. These Guernseys would be served with Devon bulls, and the progeny crossed again; this would probably go on for generations, so long as the cross maintained their milking qualities. It is evident that the Guernsey blood would be in time distributed amongst the whole of the herd, in consequence of selecting heifers with a little of the blood in their veins, in order to get good milkers. As pedigree, until lately, has not been considered amongst the breeders, no doubt the bulls, too, would have some of the same blood, and the breed has in this way been established.

The colour is much lighter red than that of the North Devons, being occasionally almost yellow. They are much larger animals,

being generally both high and long, but as young stock are narrow and rather flat-sided, although when arriving at maturity they thicken and lay on flesh very rapidly.

In some parts of Cornwall they are much preferred to the Shorthorn, as they possess good constitutions, and keep in much better condition on the poorer classes of food, such as straw and turnips. They are also well adapted to grazing.

They are excellent milkers, and altogether very useful cattle and well suited to the locality in which they are bred. Many attempts have been made from time to time to introduce North Devons, Shorthorns, Jerseys, and even Aberdeen Angus into South Devon, but none of these breeds have proved themselves so suitable to the locality as the native breed.

The **Sussex** cattle were originally very large, coarse, strong animals, and chiefly bred for draught purposes. After they had

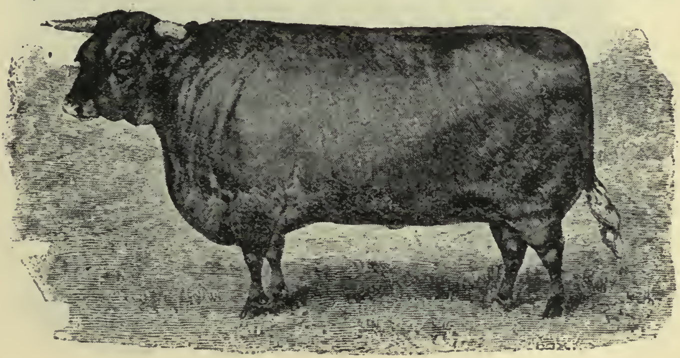


FIG. 68.—Sussex Bull.

been worked for some years, they were fattened for the market, when they made great weights. They were always exceedingly hardy animals, and well suited for grazing on poor coarse pastures.

As times altered and horses began to take their places in teams, their breeders had to hold other things in view, and consequently get their cattle more adapted to beef production than for draught purposes. In order to arrive at this end, breeders used animals with small bone and a large proportion of flesh. This selection has had its desired effect, and has produced cattle of very different type to the old Sussex. It may be seen by glancing at the Smithfield Show list that this breed comes early to maturity, and are also great favourites with the butchers. Two Sussex steers shown at Smithfield, 1891, were respectively 649 and 679

days old (1 year, 40 weeks, and 1 year, 45 weeks). The weight of dressed carcase was 936 and 995 lbs. respectively.

The colour of the Sussex cattle now is a uniform red, not unlike the Devon in this respect. The original oxen were not so uniform in colour, being sometimes light as well as very dark red, and were exceedingly coarse about the shoulder.

They have clean bone and an attractive appearance. The head is neat, with fairly wide forehead; narrow across the face, and larger again at the muzzle, which is of a yellowish colour; eye rather prominent; longish horns, inclined upwards at the points; the chest is wide between the fore legs, and should project well forward; fairly deep in the girth; back and sides straight, but rather narrow and light over the hind quarters; legs moderately long; the coat is soft and mellow.

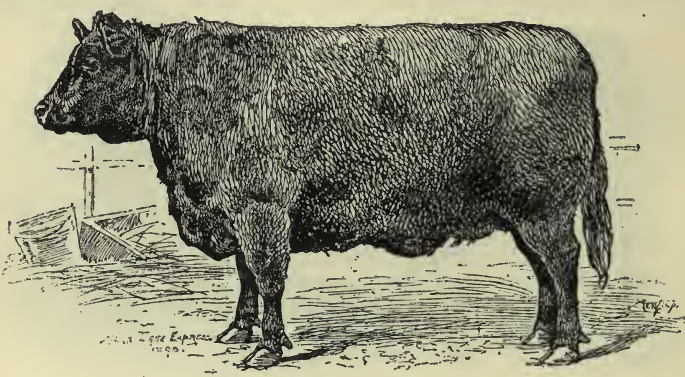


FIG. 69.—Cross-bred Heifer.

They are an exceedingly hardy breed, and appear to be better adapted to the pastures of their county (which are sometimes very poor) than any other breed.

The cows are poor milkers, and are usually allowed to suckle their calves. A common practice with the Sussex farmer is to get his cows to calve at the back end of the year (October and November). The calf is suckled during the winter, and then a purchased one is put on the same cow in the spring, after weaning the first, so that each cow rears two calves.

The **Red Polled Cattle** of Norfolk and Suffolk have originated from the native cattle of these counties, which may have at one time received a little of the Galloway blood.

By many people it is considered that these "Red Polls" are merely red Galloways, whilst many Norfolk and Suffolk men deny

the fact of their having any Galloway blood in them, and consider that they have originated entirely from the native breeds.

The native cattle of Norfolk were a red, horned breed. Those of Suffolk were dun-coloured, and polled. Later on they have been described as being red, and white, and brindled. From the earliest periods they have been renowned for their milking qualities. From very early times large numbers of polled Galloways were driven into Norfolk and Suffolk for grazing purposes, and it is only likely that some of these cattle were crossed with the native breeds, and from these crossed cattle, with careful selection, the "Red Polls" of to-day may have been produced. It may be long since any of the Scotch blood was used, but from all that has

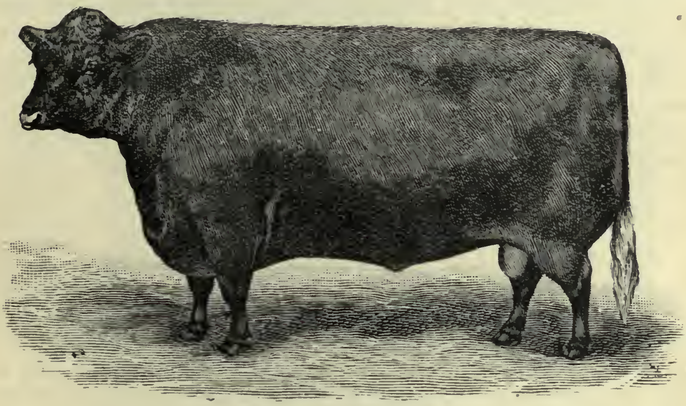


FIG. 70.—Red Poll Bull.

been recorded respecting the breed, we may justly believe that it has been used, though perhaps to a small extent.

The Red Polls are dark-red in colour, with a neat head carrying a tuft of hair on the top. They have good shoulders and are fairly square in frame, but are inclined to be a little wanting behind the shoulders, and also in the hind quarters.

They are a medium-sized breed, with a very good constitution, and more suitable to the poorish pastures, cold winds of winter and spring, natural to their own counties, than most other heavier breeds.

They are excellent dairy cattle, and hold their milk for longer periods than most other breeds. They are also good beef producers, having a tendency to fatten quickly.

The **Longhorns**, in Bakewell's time, were a very popular breed, and were very much improved by him. After the introduction

of the Shorthorn their numbers quickly declined, and they are now confined to a few breeders in the Midland Counties.

There were two classes for these cattle at the R.A.S.E.'s Show at Windsor, 1889. The entries numbered eleven; the male class five, and females six entries.

The Longhorns may be all colours, the brindles and pyes are perhaps the most common; but, whatever their colour may be, they usually have a characteristic white streak along the back. Their horns are long and peculiar in shape. They are shorter and thicker in the bull than in the cow, usually turning downwards towards the cheeks, and forwards at the tips. Compared with the Shorthorn, the girth is small, but the ribs are fairly well sprung, and well covered when fat; they also have good backs, loins, and long fleshy hind quarters when in flourishing condition. Their legs are fairly fine and long; hide rather thick, with good amount of hair. They produce beef of good quality, and are very suitable to grazing, but they take a long time in coming to maturity; they are considered good for dairy purposes, and the milk is usually very rich.

Scotch Cattle.

The **Aberdeen-Angus**, or "Doddies." The real origin of these cattle seems a little obscure. Although much has been written respecting this matter from time to time, the theories put forth have, as a rule, been questionable. Many writers hold that they have a common origin with the Galloways; but, whether that be the case or not, it is certain that, under the name of "Buchan Hummlies," black polled cattle were the native breed of Aberdeenshire for many long years before an Aberdeen-Angus Herd-book was thought of. The two great improvers of the breed were Mr. Hugh Watson, of Keiller, and Mr. William McCombie, of Tillyfour.

The colour of this breed is black, though white markings on the belly are not uncommon.

The general form of a good specimen of an Aberdeen-Angus is as near perfection as we get with cattle; it may well be described as a parallelogram.

They are naturally polled, head of moderate length, broad forehead, and face slightly prominent, with a tuft of hair on top of their head; neck moderate length; shoulders well covered with flesh, broad on the withers, and straight with the back; chest broad, very deep, and well set forward; ribs well sprung and well covered; broad and straight back, good loins, hook bones not prominent but well covered, rump full and level; hind quarters

deep; muscular and full thighs; legs short and well set; skin fairly thick, well covered with soft hair.

These cattle are much prized by the butchers; their beef is

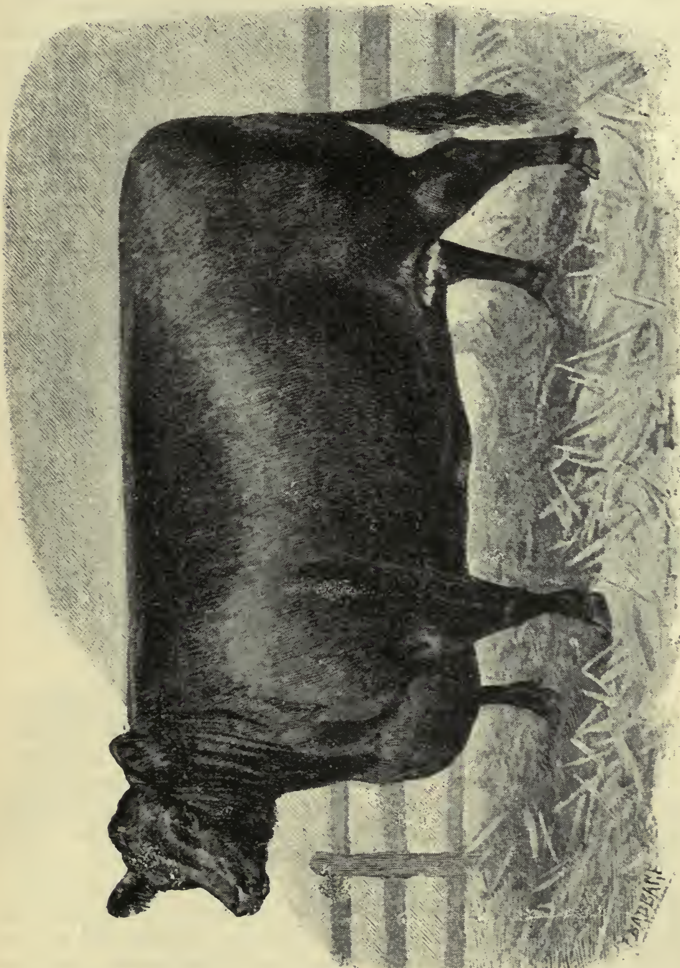


FIG. 71.—Aberdeen-Angus Heifer.

of excellent quality, large proportions being carried on the back, loins, and best selling parts.

Both the Aberdeen-Angus and the Galloways make excellent

crosses with the Shorthorn. These crossed cattle are known as "Blue Greys," and usually fetch the best prices at the Smithfield Market.

The Aberdeen-Angus, like the Shorthorns, are brought early to maturity and make great weights. They are generally only moderate milkers, though the little they give is very rich in cream. The chief aim of the breeder has been to develop beef-producing qualities, and consequently their milking qualities have usually been neglected. There have been some notable exceptions to this rule, and at the London Dairy Show in 1892 a Polled Angus cow carried off the premier honours in the milking competition.

The **Galloways** are also a black polled breed, native to the

FIG. 72.—Galloway Bull.

south-west of Scotland. They have very strong constitutions and are excellent grazing cattle. In very early periods this good quality was well known by the English farmer, consequently they were brought in very great numbers into this country for that purpose, especially into the counties of Norfolk and Suffolk. The fact of their being polled was greatly in their favour.

They are slightly smaller, rougher in their coat, and less peaked at the poll than the Aberdeen-Angus. They do not mature so early as the Angus (though this is probably due to the conditions under which they are kept), and, like them, they are not as a rule good milkers, though what they give is usually very rich. They are better adapted for grazing in exposed situations than the Angus, being exceedingly hardy in constitution.

They may be described as being a black polled breed. The

hair is very long and usually black, though red ones are occasionally seen; also the tips of the hair, when long, are often red.

The head is short, but broad on the forehead and between the eyes. The ears are large, open, and fringed with long black hair. The chest is deep and the beef well distributed; back and loins very good; hind quarters long, but often a little narrow; legs rather short. The line from the head to the rump is almost straight, but dropping slightly in the back.

For the purpose of getting Bluegreys, white Shorthorn bulls are used with the black Galloway cows; these crossbreds are

FIG. 73.—Cross-bred Steer.

usually polled, and shaped more like a Galloway than the Shorthorn. Many farmers consider the best way to produce crossbreds is to use a Galloway bull with Shorthorn cows.

The percentage of polled offsprings is greater when the polled bull is used. The colour is usually black or blue-grey, from the black male parent; the proportion of patchy colours being greater from the Shorthorn sire.

Hereford bulls are used in some cases with Galloway cows, and leave very good results.

The **Ayrshire** is purely a dairy breed. For cheese-making they are more celebrated than any other cattle we possess.

They are exceedingly hardy, and are therefore very suited to the severe northern climate. The size of the Ayrshires varies very much, according to the quality of the land on which they have been bred. They are much smaller than the Shorthorn, so can be kept on much less food. They will produce large quantities of milk on pastures that Shorthorns would be barely maintained on.

For the production of beef they are by no means valuable, consequently the second-rate bull calves are usually sent to the butcher for veal.

Ayrshires cross fairly well with the Shorthorns; the crossbreds

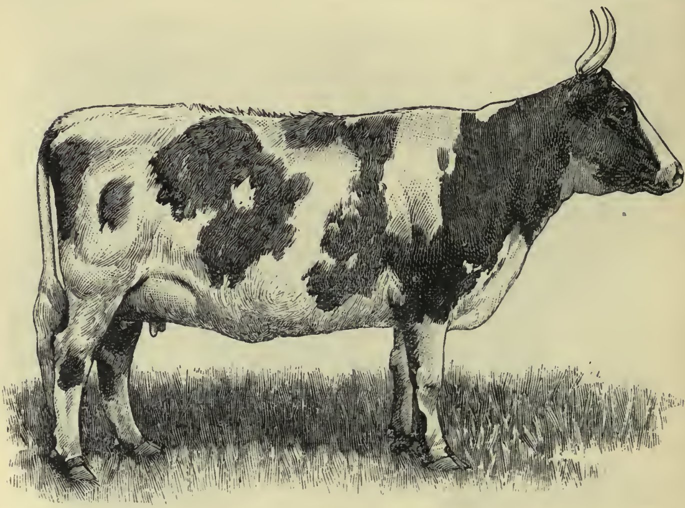


Fig. 74.—Ayrshire Cow.

are much better feeding cattle than the pure Ayrshire, and are also good milkers.

Cattle of this breed vary somewhat in colour. Brown and white, white and brown, red and white, and white are the usual colours.

Their general form is sometimes described as being wedge-shaped, on account of the body getting wider and deeper from the fore quarters backwards. That is to say, they are light in the fore, but comparatively heavy in the hind quarters. The hook bones are set widely apart, but not well covered with flesh; the back, too, is usually lean; neck long and thin, being especially small where it joins on to the head. The horns are rather large and turned upwards. The eyes are bright, the face inclined to be

long. The tail is long, thin, and bushy at the bottom. The udder is large, well hung forward, with the teats set well apart; the milk vein prominent.

The **West Highland Cattle**, or Kyloes, are found in great numbers on the hills of Scotland. They are well adapted for grazing these rough, poor, upland pastures, where they have to travel great distances for their daily food, and withstand the severe storms, to which they are naturally subjected, without taking any great harm.

They vary much in size, with the different kind of soils they are bred upon; but they are usually very small.

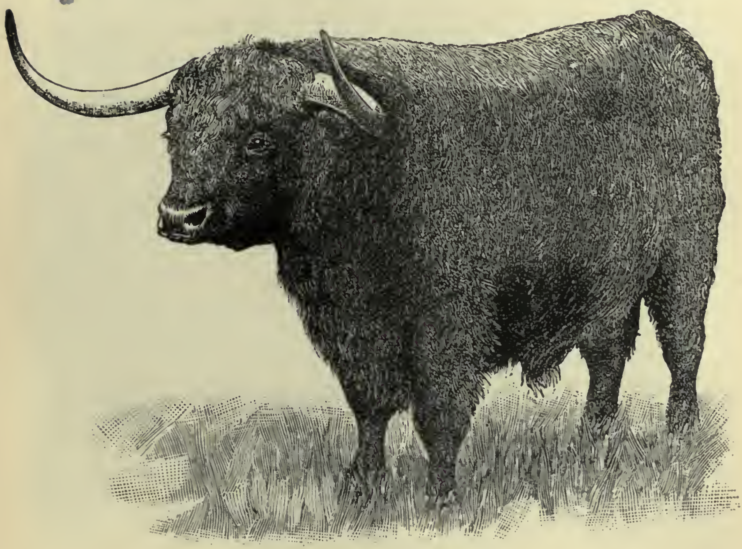


FIG. 75.—West Highland Bullock.

They differ greatly in colour, being different shades of dun, brown, red, black, and sometimes brindled. Their hair is very long and shaggy. The head is short and horns very long. Their appearance to strangers looks a little fierce. The body is stout, square, and massive; the legs are very short.

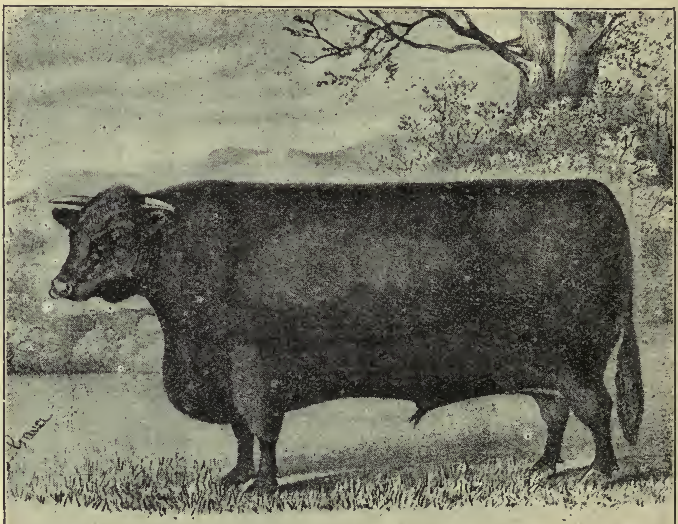
They give very little milk, but it is exceedingly rich. Being kept on these poor pastures, they are naturally very slow in coming to maturity; but their beef is of excellent quality.

When crossed with larger breeds, such as the Shorthorn, the produce make excellent beef cattle.

Other Breeds.

The **Welsh Cattle** may be divided into two breeds, viz. the South Wales cattle, or Pembrokes, and the North Wales, or Anglesea cattle.

The colour is black, but sometimes they have small white markings on the underside. Both these breeds are exceedingly hardy and well suited to the climate and rough country they have to live in. They vary a good deal in size, according to the quality of soil they are brought up on. When well cared for the oxen of these breeds make great weights. More than



WELSH BULL, "AP GWILYM" (70)

Fig. 76.

once, Welsh steers have been the heaviest of all exhibited at the Smithfield show. Unfortunately the Welsh farmers are not as a body keen breeders, consequently the improvement of the breed is left in too few hands to note the universal improvement in the breed that we might otherwise see, although in many herds most marked improvements have taken place within the last few years.

These cattle are driven in great numbers to the Midlands and Eastern Counties, where they are used for grazing purposes, and are usually well liked for this purpose. They are favourites with the butcher as well as with the farmer. The South Wales cows

are good milkers, much better than the North, and usually have a finer coat than the Anglesea cattle. The Angleseas are thicker set, shorter on their legs, a little coarser on their fore, but much better on their hind quarters than the Pembrokes.

The **Jerseys** for butter-making excel all other breeds; but, being rather delicate in constitution, they are better adapted to the southern than the northern climate. For beef-production they are of very little value: they take a long time to feed, and when fed they make light weights and carry only a small proportion of their beef in the choice parts.

FIG. 77.—Jersey Cow.

They cross exceedingly well with the Shorthorn. The crosses retain to a great extent the dairy qualities of the Jersey, and are far more valuable as beef makers.

They are commonly used in the south of England for dairy purposes. Many people keep a Jersey cow to every six or seven of other breeds; by so doing, the colour and consistency of the butter and cream are improved, and the cream is supposed to be more easily churned. They are also very much used in small dairies for private families.

As a breed they have a very characteristic appearance,

being small and fine boned. The usual colours are different shades of fawn, grey, silver grey, sometimes brown and broken colour.

FIG. 78.—Jersey Bull.

The head is small and neat with rather small crumpled horns,

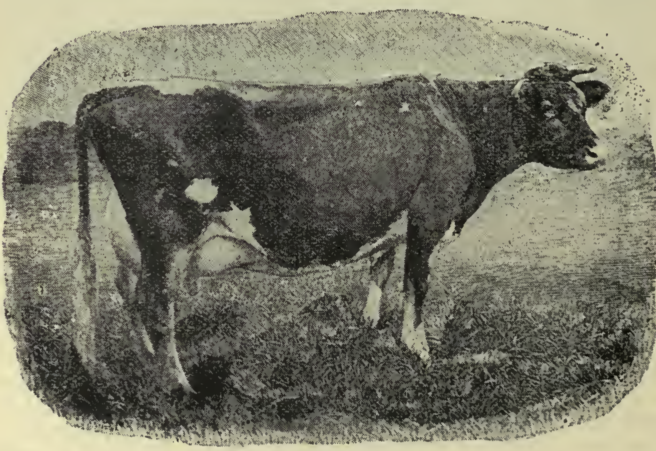


FIG. 79.—Guernsey Cow.

eyes black and prominent, nose black, the nose and eyelids are

encircled with yellow hair. The neck is thin, back straight and not well covered with flesh, bones of the hind quarters prominent, barrel very full and deep, girth comparatively small, coat fine, short and sleek (not turned), udder of fleshy colour and well hung, milk veins prominent.

They are more famous for the quality than quantity of their milk; it is exceedingly rich in butter fat.

The **Guernseys**, like the Jerseys, are Channel Island cattle; they

Fig. 80.—Kerry Cow.

have very much the characteristics of the Jerseys. Although these are the breeds of the islands, many of the best animals of both kinds are bred by English farmers. The Guernseys are larger, and deeper milkers than the Jerseys, but the milk is not quite so rich.

In form they are very like the Jerseys, but differ in colour, usually being fawn and white, and sometimes red and white.

These cattle, too, cross exceedingly well with the Shorthorn; as regards beef the resulting animal is superior to the Jersey and Shorthorn cross. Many of these cross-bred cattle are found in the south of England.

The **Irish Cattle** may be divided into two breeds—the Kerries, and Dexter Kerries. These are very small but exceedingly hardy cattle, and well adapted for grazing on poor land, or suited for a poor man with only a small allotment. Of the two the Kerries are the better milkers; they produce a large proportion of milk in comparison with the amount and quality of food they consume.

The colour of the Kerries is black, and in form they are very like the Ayrshires, but are much smaller, and have longer hair.

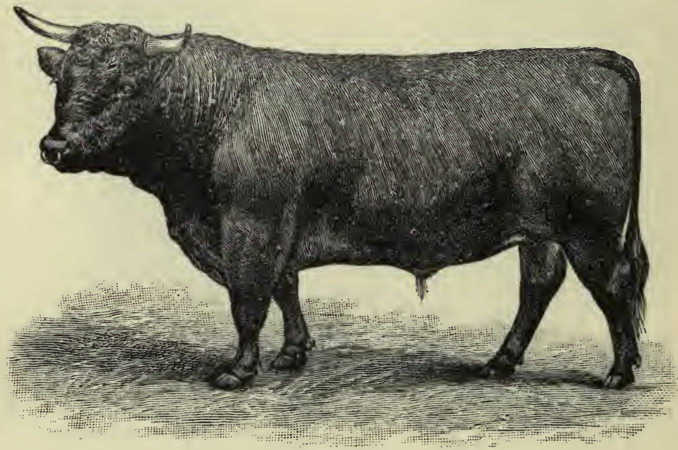


FIG. 81.—Dexter Kerry Bull.

The Dexter Kerries are also often good milkers, but more adapted to beef production than the Kerries. They usually have long black hair, sometimes red, and blue-grey. They are thicker and better made than the Kerries, their bones being much better covered; in fact, some of the red specimens have more the appearance of a miniature Shorthorn than an Ayrshire. Both these breeds are kept by Martin J. Sutton, the noted seedsman of Reading, who usually figures well in the prize list where these breeds are shown.

PRINCIPLES OF BREEDING.

Every breeder who tries to improve his herd, flock, or stud should hold certain objects in view, in order that he may eventually produce points of excellence in his stock. These points would, of course, differ according to the animals he went in for breeding. A man who breeds without a definite object,

or without holding in his mind's eye an ideal animal, and trying to his best ability to produce such animals, will usually meet with unsatisfactory results.

There are a few well-known and accepted principles which should be studied by all young breeders, as the good and bad results are to a very great extent under a man's control; although occasionally good and bad points appear as mere matters of chance.

The first thing to be remembered is that "*Like begets like;*" that is, the peculiarities of the parents are likely to appear in the offspring. This is known as the Law of Heredity.

Spontaneous Variation.—Although the law of "Like begetting like" is true in the general sense, it, like all other rules, has its exceptions; hence we get spontaneous variation cropping up in all kinds of breeding. That is to say, the offspring is unlike, and sometimes very unlike its parents, or any of its ancestry. These variations often amount to freaks of nature, and cannot in any way be accounted for.

Besides this spontaneous variation we also get variation appearing in a less marked degree, simply caused by changes of climate, food, or soil, on certain breeds. For instance, mountain sheep, when kept for a few generations in better climates, and on stronger soils, will often differ in having finer quality wool, and better developed carcases, than the original breed. The same with the Highland cattle when taken to the parks in the south of England; after a few generations they lose, to a certain extent, that large development of hair, which in the Highlands is necessary for protection, whilst in the mild climate of the south of England it is not required.

Spontaneous variation is less likely to occur in animals that have been bred, for many generations back, to a uniform type, than when the contrary is the case.

Atavism, or "reversion." "Throwing back," "breeding back," frequently occurs in even well-bred stock. It means that certain characteristic points possessed by the ancestors of generations back are transmitted to the offspring, although not possessed by the parents. An example might be taken in the case of Galloway cattle developing horns, which is occasionally the case; although these cattle have been bred as polled beasts for many generations, yet at some time, no doubt, the cattle from which the breed has sprung, had horns.

Cases of reversion are often interesting in helping to show the origin of our different breeds. It is sometimes very difficult to decide as to whether a case is reversion or spontaneous variation.

Prepotency.—Some animals have greater powers of transmitting their characteristic points to the offspring than others, consequently

the offspring is most like the animal that possesses the greatest prepotency. As a rule the male is supposed to have a greater power of transmitting his points than the female, but this is by no means always the case.

Of two animals the one that has the longest pedigree, or is the better bred, is usually the one that possesses the greatest power of transmitting its characteristics to the offspring.

Heredity.—None but the best animals should be selected to breed from, as the points of the parents are usually inherited by the offspring; and, as a rule, there is a much greater chance of the weak points being inherited than the stronger ones. The weak points, too, are often intensified in the offspring; consequently animals with any constitutional weakness should never be bred from.

The offspring is usually considered to inherit more of the size and outward appearance of the male, whilst it resembles the female in a greater degree as regards its internal organs and constitution.

"**In-and-in Breeding**" means mating animals that are closely related to one another. This practice of family breeding is not carried on to the extent it was at one time, but it is still done. It is no doubt the quickest way of establishing a uniform breed of animals, but it is often attended by a loss of size and constitution. The great danger is that there may be a constitutional weakness running through the cattle, and family breeding has the tendency to intensify this weakness. Consequently, if this practice is to be carried on successfully, very careful selection has to be resorted to, and only the most robust animals, which show no signs of weakness of any kind, should be selected from, and those possessing any fault should be weeded out.

It is, as a rule, advantageous to introduce blood from other families; by this means faults may be remedied, by selecting a male with strong points, where, perhaps, the female may be slightly weak.

Selection.—There are a vast number of points that have to be taken into consideration with regard to selection, varying much with the breed of animals that are dealt with, and also with the different purposes for which they may be required. In every case animals most likely to leave stock best fitted for the different purposes that they may be required for, should be selected.

In the wild state we get the survival of the fittest, the weaker ones either die from disease, or are killed by their betters, and only the strong and robust animals are allowed to live. With our domesticated animals we have to go in for artificial selection, and only breed from the fittest.

In selecting for breeding purposes, it is necessary to look into

the pedigree and ancestry of the animals, as well as choosing good-looking stock. It is sometimes the case that good-looking cattle, sheep, or horses may be got by one good and one inferior parent; in such a case the stock got from such animals will probably possess some of the bad points of the undesirable ancestor, instead of possessing the good points of the parent.

A plain bull, whose ancestry have all been good specimens of the breed, will usually produce much better stock than a good-looking bull derived from inferior stock.

It is, as a rule, bad policy to select stock from a very strong soil to improve stock on poor land. The change in the quality of the food will usually be felt, and will prove insufficient to keep up the development of the animals, and consequently the change will be accompanied with a loss of form, instead of producing cattle similar to those from the strong land.

Crossing usually means mating animals that are purely bred, but of two distinct breeds, such as mating a pure-bred Shorthorn with a pure-bred Galloway.

The first cross is usually the best, as it usually embraces the good characters of both breeds, whilst a second cross often produces stock which lack uniformity.

Crossing is carried on extensively amongst cattle and sheep, for the purposes of producing size, good quality meat, and early maturity, to meet the requirements of both the farmer and the butcher.

For producing size and early maturity, males of larger breeds possessing the quality of coming early to maturity are usually used with smaller females. We see such results most pointedly amongst hill cattle or mountain sheep. If Highland cows are served by small Shorthorn bulls, the size will be much improved, and they will be almost equal to the Highland cattle as regards constitution. But if Shorthorn cows are served by Highland bulls, they would not have such strong constitutions, and would not be nearly so suited to hill grazing as if crossed the other way.

The same thing may be noticed in sheep; take, for instance, the crossing Cheviot ewes with Leicester rams. The size is improved, they come early to maturity, and have strong constitutions. But if a Cheviot tup were used with Leicester ewes, the cross would not be so well adapted for upland pastures as when the half-bred is got from the Cheviot mother.

A "*pure bred*" animal is one descended on both sides from animals belonging to any one of the recognized pure breeds.

A "*cross bred*" animal is one that is the offspring of parents of two distinct breeds.

A "*grade*" is the offspring of parents one of which is pure bred, but the other not.

A "*high grade*" is an animal of mixed breeding, in which the blood of pure-bred animals largely predominates.

Soil and Climate influence to a certain extent the characteristic points of live stock. This is most strikingly seen in breeds that live entirely on the natural produce of the soil, and are exposed to the natural climate, such as mountain sheep and Highland cattle.

The influence of soil and climate is, perhaps, best known to the farmers in the Highlands of Scotland, who have found from experience that, in taking over a farm, it pays them best to take the sheep that have been bred on the farm, with it, although they may cost a great deal more than they might be purchased for elsewhere. The death-rate of strange sheep put on the farm would probably be very great until they became acclimatized.

Every sheep-breeder knows that climate and soil have a great influence on wool, and will consequently be particular in selecting rams from certain districts to improve their wool if necessary. To take an instance, the South Ham sheep are well adapted to the Cornish climate generally, yet the breeders frequently find a falling off in the weight of the fleece, and go to Devonshire for their rams in order to remedy this failure.

The reasons for mountain breeds being more influenced than others by soil and climate are, because they usually have to live on the natural pasture, and are exposed to the natural climate; whilst other breeds are often artificially fed, and are also provided with shelter, and are therefore less exposed to the natural influences of soil and climate.

Management of Cattle.

The first thing we will consider under this heading will be the **Selection of Stock.** From what has been already said in describing the different breeds of cattle, it will be seen that some breeds are more suited to some localities and climates than others. So there are many things that should be taken into consideration before selecting any particular breed of cattle, in order that they may be adapted to the kind of farming, and land for which they may be required.

The chief points to be considered may be summed up as follows:—(1) Climate; (2) Quality of Land; (3) District, or Locality; (4) Kind of Farming, viz. dairying or beef-producing.

Climate.—For cold and exposed northern climates, only the hardier breeds should be selected; such as the different Scotch breeds, Shorthorn, and Welsh. For milder and more southern climates more delicate breeds may be selected in addition to those suited to more severe situations.

The **Quality of the Land** must in all cases influence selection, the larger breeds being suited to the richer classes of soils, and the smaller and hardier races for the poorer class of land. Cattle should not, as a rule, be brought from a richer to a poorer soil, as such a change will probably be accompanied with a loss of symmetry, deterioration in size, weakness of bone, less aptitude to fatten, and later maturity. The quality of the food grown on the farm will be poorer in direct proportion with the quality of the land and manure used. So, to make up for this, a larger amount of artificial food will have to be used, in order to keep the cattle in such good condition. On the other hand, cattle should not be brought from a very poor soil to a very rich one, as they will not be large enough to make the best use of the richer food; but this will generally be a better change than from a richer to a poorer soil, although in some cases the superior quality of food produces such diseases as black leg or black quarter amongst cattle, when brought to a much richer soil than they have been bred upon. When cattle are brought to a better soil than they have been accustomed to, the breed will get larger in frame, and develop a greater aptitude to come early to maturity. It should always be the aim in such cases to avoid extremes, and select cattle from a slightly poorer soil than they will in future have to live on.

District.—The general farming of the district may be arable or pasture, so, in selection, these points should be taken into consideration. Some breeds are much more adapted for pasture than arable land, especially when they have been bred for years on pasture. In the same way, other breeds may be more suited to arable land, and appear to be adapted to producing beef or milk from the consumption of roots and dry foods, of which straw may form a major part.

Cattle that have been bred for generations in a locality are usually better adapted to their own natural soils than other breeds. For examples we might take the Herefords, Devons, Sussex, West Highland cattle, Ayrshires and Galloways; although the Shorthorn can generally adapt itself to most circumstances and districts, providing the land does not fall too low in quality.

Kind of Farming.—This may be divided under several headings, viz. Breeding, Rearing, Dairying, and Beef-producing.

To be a successful breeder a man should have a large capital, fairly good land, and, most important of all, a natural talent and inclination in this direction, combining foresight and good judgment, which may be brought nearer perfection by long experience. It need scarcely be mentioned that such a man will not be found in the ordinary average farmer, and, even if it were so, it is

exceedingly doubtful as to whether breeding would be the most profitable course to pursue in many cases.

Rearing is usually carried on in districts which are hilly, and contain a large amount of the poorer class of land, which will maintain young stock and cows with the addition of a little artificial food, but is not so suited for fattening cattle. The practice is to sell stock in lean condition to some neighbouring farmers on a better class of soil, where they can be fattened. This kind of farming is also practised to a small extent amongst Cumberland farmers, farming on good land, their plan being to feed their calves well until they are about twelve months old, and then sell them in the spring to graziers on rich soils, such as the Holderness, in Yorkshire. These yearlings, when well brought out, fetch from £12 to £14 per head. In their place are purchased Irish or Scotch, from two to three years old, for less money; and as they have in all probability been accustomed to poorer fare, thrive very rapidly on the Cumberland soils, with the addition of a comparatively small amount of artificial food.

Dairying.—Various circumstances may guide a man as to whether it will be better to go in for dairying or beef-producing. Generally speaking, it will usually be better for him to take up the one that he has had most experience in; but, after this, the following circumstances should materially influence his selection: (1) whether the land of the district has, or is likely to prove itself valuable for the production of milk, butter, or cheese; (2) the state of the supply of pure and fresh water; (3) distances from large centres of population; and (4) facilities for conveying the dairy produce to these centres. If these circumstances appear satisfactory, the probabilities are, that dairying will be the best plan of management to adopt.

Beef-producing.—If, on the other hand, the farm is at a great distance from well-populated districts, and the railway communication not close at hand, or any other circumstances which seem opposed to dairying place themselves in the way, and thus reduce the prospect of profit, the next best thing will be for a man to turn his attention to the production of beef, and such stock should be selected as will be considered suitable in each case.

For the guidance of the student a table has been drawn up (see next page) showing the various breeds of cattle that might be suitable under various circumstances.

As regards the management of cattle, the main object of the British farmer must be to produce beef and milk profitably, at market price. In order to do this we must have good stock; that is to say, cattle that will, with good management, produce large quantities of rich milk, or, if required, produce a heavy

BREEDS SUITED TO DIFFERENT CIRCUMSTANCES.

Climate	Breeds	Soil	Breeds	Land	Breeds	Dairy.	Beef.
Mild Climates.	Shorthorn Norfolk Polls Hereford Devons—North, South Sussex Guernsey Jersey Kerry	Rich Soils.	Shorthorn Norfolk Polls Hereford Guernsey Jersey Devon	Arable.	Shorthorn Norfolk Poll Jersey Guernsey S. Devon	Shorthorn Norfolk Poll Guernsey Jersey South Devon	Shorthorn Norfolk South Devon
				Pasture.	Hereford Shorthorn Devons—North, South Guernsey Jersey	Shorthorn South Devon Guernsey Jersey	Hereford Shorthorn North Devon South Devon
		Poor Soils.	Devons Sussex Kerry Ayrshire	Arable.	Devons Sussex Kerry Ayrshire	S. Devon Kerry Ayrshire	Devons Sussex
				Pasture.	Devons Sussex Ayrshire Kerry	Ayrshire Devons Kerry	Devons Sussex
Severe Climates.	West Highland Galloway Ayrshire Angus Shorthorn Welsh Kerry	Rich Soils.	Angus Galloway Shorthorn Ayrshire Welsh	Arable.	Angus Galloway Shorthorn Ayrshire Welsh	Shorthorn Ayrshire Welsh	Angus Galloway Shorthorn
				Pasture.	Angus Galloway Shorthorn Ayrshire Welsh	Shorthorn Ayrshire Welsh	Angus Galloway Shorthorn
		Poor Soils.	West Highland Welsh Ayrshire Galloway Kerry	Arable.	W. Highland Welsh Ayrshire Galloway Kerry	Welsh Ayrshire Kerry	Galloway Highland Welsh
				Pasture.	W. Highland Welsh Ayrshire Galloway Kerry	Welsh Ayrshire Kerry	Highland Galloway Welsh

carcase of good quality beef at an early age, and at the same time develop a hardy constitution. In order to get and retain these good qualities, careful selection and breeding is necessary. Much of the success or failure in the future will depend on the breeding of the present generation, in the same way as we have been to a very great degree dependent upon, and have to thank, such men as Messrs. Collings, Booth, Bates, Cruickshank, Watson, McCombie, etc., for the superior class of stock we possess in the Shorthorns of the present time. These men had to strike out lines of their own, and, in order that their stock should not revert or throw out bad points which might have been possessed by their forefathers, only beasts with the longest pedigrees were safe to breed from. Although a bull without a pedigree might have been in many cases a better developed animal than the one with a pedigree, yet the stock got by the non-pedigree beast would, in all probability, show bad points, which had been characteristic of some of its ancestors. So to prevent this, in many cases in-and-in, or family breeding, had to be resorted to. The tendency of line breeding in cattle is, as with all other animals, to produce degenerate stock, and cause weak constitutions, etc. So, when possible, line breeding should be avoided. In the days of Booth and Bates there was a comparatively small number of choice stock to select from, so they had to use cattle that were closely related to each other; but such is not the case in the present day, for it is not hard now to find plenty of good beasts that can date back quite far enough for breeding purposes. A strong, robust animal, with a deep and wide chest, thick through the thoracic cavity, showing signs of good constitution, and carrying beef in the right places, with only a short pedigree, providing it is sound as far as it goes, should be selected in preference to an animal showing signs of a weaker constitution, although its pedigree may be traced back many generations. In this way our breeds may be improved, and the kind of stock we require may be raised.

The question suggests itself, What class of men should go in for breeding? If we say the tenant-farmer, it is as good as implying that all British farmers should turn to breeders. If we could export all animals not required at home, for large prices, it would pay; but every reasonable person knows that the demand would not be equal to the supply, and thus the market would be glutted. Although these beasts would not be produced at butchers' prices, many of them would have to be sold at that rate, and, consequently, at a loss. Breeding, in any case, may be considered a speculation, and should be left to men of means, who wish to win honour and renown rather than money. Many highly bred beasts have to fall to the butcher's pole-axe at tender ages as

it is, at a loss to their breeder; and if breeding were taken up extensively by the tenant-farmer, it would be the fate of an increased number, thereby causing a greater loss; therefore, as before mentioned, it should be the aim of the British farmer to produce beef and dairy produce profitably at the market prices, whilst the breeder should breed with a view to produce a class of stock which would be likely to assist the tenant in attaining this object.

Calf-rearing.—In order to describe the life history of an animal or plant, it is usual to start with the embryo, or seed, so we will do so in this case.

If a good calf is desired, perhaps the best way of obtaining it will be to select a dam which possesses, as nearly as possible, the points and good qualities required in the calf, and let her be bulled by a beast that would be likely to prove a desirable sire. The next point will be to keep the dam in a healthy and good condition during her period of gestation, which is usually considered to be 285 days, roughly nine calendar months. It is by no means usual for cows to calve at the exact day they are due; they sometimes calve before that time, and often after. If the calf is dropped before the cow has gone her full time, the probability is that it will be a heifer calf, and if she goes beyond the time, a bull calf is usually the result. Physiologists, I believe, account for this fact on the assumption that the female organs differ from those of the male in being in a much less developed state; but be this as it may, the fact remains that the larger proportion of calves born after the normal time has expired are males.

If the animal bearing the calf is a milking cow, she should be dried at least two months before she is due to calve, and should be supplied with wholesome and nutritious food, as it must not be forgotten she has the fœtus to supply with sufficient nourishment, so that it may be a strong and well-developed animal at birth. The constitution of the calf will be influenced very much by the style of feeding the mother gets during the last stage of her pregnancy. Cows meanly fed and ill-cared for at this stage, often produce calves with a weak constitution, which they rarely shake off during their after life, and, consequently, prove unprofitable. The best managers keep cows at this period in a good healthy condition, without allowing them to get too fat. When allowed to get too high in condition, there is a great chance of their getting a severe time during parturition, and are much more liable to fall victims to milk fever and other parturient complaints, which so often prove fatal to cows kept in high condition, and yet are comparatively unknown amongst herds which lack flesh at this period.

As soon as a cow shows signs of coming parturition by the

dropping of the pelvic bones, distention of the udder and teats, etc., she should be placed in a comfortable, well-bedded loose box, so that she may become thoroughly accustomed to her new abode before the arrival of her progeny.

Some people give a calving drink before parturition takes place, as a preventative of milk-fever, and, in the case of very heavy milkers, some milk may be taken a day or two before calving. Such a drink might consist of small doses of linseed oil or Epsom salts, which may be started about a fortnight before the time of calving. A sloppy bran mash or two may be given with advantage at this period.

The methods of rearing calves vary very much in different districts, and with different styles of farming. For instance, the modes of management with a breeder and a dairyman will be almost directly opposed to one another. The breeder would probably give his calves almost as much as they would take, whilst the dairyman, with a good sale for his milk, would supply them with only the bare quantity he considered necessary.

Some farmers on grazing land simply let the cows suckle their calves, as on the pasture lands of Herefordshire, this system being much like the breeders'. Then, again, in some districts where dairy produce is not saleable, farmers go in for beef production, and bring up as many purchased calves, in addition to their own, on the milk from only a few cows, their system being much like the dairyman's. Besides these, we have the general farmer, who goes in for a style between the two, giving plenty without being too lavish.

To take *the breeder*. If his object were to produce beef at market price no doubt he would be a little less liberal towards his calf than is usually the case. He has to look at things in a different light; his object being to bring his bulls out in show condition at twelve to thirteen months old, so that they may attract the eyes of the buyers, and compete favourably with other competitors. In order to do this, the calf has to be forced beyond its natural growth, with expensive food; but as they usually fetch sums far beyond their value to the butcher, the cost of the food is not begrudged. It is often argued that, if these beasts were kept in a less pampered and a more natural condition, their health and breeding qualities would be improved.

But when a beast is brought into a show or sale ring out of condition, no one is to know that it has had food inferior to the best-fed beast in this class, and is consequently at a disadvantage, generally being smaller and less sightly. The poorer condition is often put down to less constitution and aptitude to thrive, weak points are also more plainly seen in a lean than a fat beast.

Some good judges, it is true, would rather trust to their judgment and buy the animal in a less pampered condition, but this is the exception rather than the rule, for it is usually the animals best brought out that appear to the best advantage.

The bull calves are often allowed to suck their dams until they get dry, when the calf would be from seven to nine months old. In addition to the milk they get from their mother, they begin to eat cake, hay, roots, etc., when about a month old, and are given as much as they will consume, which will be very little at first; but at eight to ten months old the cake and meal might amount to six or seven pounds per day. After being weaned from the mother they often receive an allowance of skim milk.

The heifer calves as a rule do not get such a liberal fare; one cow is often allowed to suckle two calves, or perhaps they may be weaned at two or three weeks old, when they would be kept on whole and skim milk mixed.

In grazing districts, such as Herefordshire, the calves are often allowed to suck their dams. The management is so arranged that the cows may calve in spring, the calf being allowed to run with the mother at grass until she becomes dry, the cow will not be hand-milked at all, excepting for the first few days, when she gets a little taken off to prevent her teats becoming hard, until the calf is able to suck her fairly dry.

The expense of this system will be considered later, under the head of "Herefordshire Management."

In some cases, where the cows are fairly good milkers, they are made to maintain two calves; they naturally make smaller calves than when only one is suckled, but this system is much more economical. It is also a common practice to put a pair of calves on one cow for about three months; they are then weaned, and a third one put on for the remainder of her milking period.

Another and perhaps less common practice is to get an old dairy cow after she has had her last calf, with the addition of a little skim milk, to bring up as many as five calves. It may be arranged as follows. At first, two are put on her, and weaned from ten to twelve weeks old, when two more are put on for another twelve weeks, and after these are taken away she will maintain one for the remainder of her milking period.

It is a common practice to take calves from heifers not required to replace other cows in the dairy, these being allowed to calve in early summer and run three or four months on the pasture with their calf; they are then dried, and fed for the butcher, under four years old.

We will now consider a general way of bringing up calves, or a system that might be suitable in any district, and especially

so for a farmer who wished to bring up more than his own bred calves, as is often the case. When such a farmer requires calves he can usually get well bred ones from a dairy farmer, at from £1 to £1 10*s.* per head.

We will suppose that an attendant is present when the cow drops her calf; it is taken away and put in a calf-hutch, and, when rubbed dry with a wisp of straw, given a little of its mother's first milk, or beistyns (colostrum). This first milk that a cow produces after calving is very different to her ordinary milk. It contains a high percentage of albumin and casein, and a much lower percentage of water. It has a much higher albuminoid ratio than ordinary milk. The first three or four milkings are unfit for butter making.

COMPOSITION OF ORDINARY MILK AND COLOSTRUM.

	Of Ordinary Milk.	Of Colostrum.
Water	87·5	78·8
Fat	3·5	4·0
Casein	3·3	7·3
Sugar	4·6	1·5
Albumin	0·4	7·4
Ash	0·7	1·0
	100·0	100·0

Colostrum has peculiar properties, and has a purgative action on the bowels of the young calf. It is necessary that the calf should be fed on this colostrum in order to clear the intestines of the brown gluey fæces contained therein.

It is sometimes a little difficult to get the calf to take its milk at first, but with patience the most stubborn may be made to take it. If the finger be placed in their mouth they will usually begin to suck it, especially if the roof of the mouth be tickled; then, by placing the mouth, with the finger in it, in some milk it may be got to suck up about a pint and a half at a time. It should get this quantity about four times a day, and a little more at its last meal at night. By about the third day it will take about a gallon in three meals; and by the end of the week about five quarts per day. It should have its mother's milk for at least the first week. The second week it will require nearly six quarts a day; third week, about four quarts of whole milk and three of skim; fourth week, two of whole and six of skim. After this the whole milk may be stopped, and its place supplied by linseed boiled with a little wheat flour.

Three pounds of linseed with one of flour would make about five gallons of gruel; this, mixed with six gallons of skim milk, would be sufficient for five calves for one day, and should keep them well after a month old.

The cost of the milk and gruel per week would be about two shillings for each calf.

		s.	d.
6 gallons skim milk at 2*d.* per gallon	.. ..	1	0
3 lbs. of linseed, 1 lb. of flour	at about $1\frac{1}{4}$*d.* per lb.	0	5
		1	5

Five calves would cost one shilling and fivepence per day. Therefore one calf would cost about two shillings per week. One pound of linseed contains about as much fat as one gallon of whole milk, therefore the composition of the mixture would be almost the same as the same quantity of whole and skim milk mixed in equal quantities. The price would be less than half.

	d.
One gallon whole milk	6
One gallon skim milk	2
	8

Giving two gallons per day, or fourteen gallons per week, would cost four shillings and eightpence, whilst the first mixture would only cost two shillings per week.

Some feeders give gruels prepared from ground linseed-cake and maize meal, but pure linseed is to be preferred, as the composition of the mixture approaches much nearer the composition of the natural food. The linseed supplies to a great extent the fat that has been removed for butter-making. It contains from three to four times as much fat as these other foods. Again, linseed cakes are often adulterated with rape seed, etc., in which case they have a peculiar acrid taste, and sometimes cause the calves to scour.

It may be found, in some cases, that the addition of this linseed makes the food of too laxative a nature; in this case the gruel should be made for a short time with two pounds each of bean meal and linseed, and gradually got back to three pounds of linseed and one of bean meal or wheat flour. The following table will show approximately how much a calf will require for the first month.

First day, about $1\frac{1}{2}$ pints three times during the day, and 1 quart at night.
Second day, 4 quarts in three meals.
Seventh day, 5 ,, ,,
(Or the calf may be kept with its dam for the first week.)
End of second week, 6 quarts in three meals.
,, third week, 4 quarts of new and 3 quarts of skim milk.
,, fourth week, 2 ,, ,, 6 ,, ,,

After a month, if milk is scarce its place may be supplied by a little over two gallons of mixed gruel and skim milk (as described) per each calf per day, to be lessened after ten, and entirely discontinued at fourteen, weeks.

A calf at a month old will begin to eat cake, crushed oats, hay, and sliced roots in very small quantities.

When entirely weaned from its milk and gruel it should receive about one pound of linseed cake or crushed oats per day, in addition to hay and a few sliced roots.

Mr. Bowick on "Calf-rearing," in the *Journal of the Royal Agricultural Society*, vol. xxii., p. 136, gives a whole-milk diet for a calf:—

First week with the dam, or 4 quarts per day.
Second to fourth week, 5 to 7 quarts per day.
Fourth to sixth week, 6 to 7 quarts per day.

The quantity need not exceed two gallons per day during the ensuing six weeks, after which time the calf is weaned.

It is a disputed point as to whether the calf should be allowed to suck its dam or taken away directly after it is born. Strong arguments may be raised on either side, but the generality of farmers appear to be in favour of taking the calf away as soon as it is dropped; our own experience, however, leads us to consider the practice of leaving the calf and dam together for a few days the better plan. It is undoubtedly the more natural one for both the cow and the calf.

The chief objection raised against this practice is, that the cow is not supposed to milk so well afterwards. This, to a certain extent, may be true, but, under proper management, as a rule there will be no appreciable difference. Whilst the calf is with the mother she should have a little milk taken off twice a day; by this means she is kept fairly dry. It is a common practice in Devon and Cornwall to leave the cow and calf together for from four to eight days, and the cows usually hold their milk up to within eight weeks of calving. South Devon cattle are known to be good milkers, so also are the cross-bred Shorthorn and Alderney cattle of Cornwall, in spite of this system, which has been practised for generations, and supposed by some to be so deleterious to their milking qualities. But allowing that it is a slight detriment to the milk production of the cow, there are many things in its favour that will more than balance this fault.

1. The mother gets the medicine that nature has provided for her from the viscous matter covering the coat of the young calf.

2. The sucking action of the calf is more natural and better at this critical period, than milking entirely by hand.

3. The calf gets the use of its limbs much sooner if licked by its mother; the friction of her rough tongue produces a far better circulation, greater warmth, and a much drier coat than can be obtained by rubbing with a wisp of straw.

4. The calf is able to help itself when it requires milk, taking it little and often, so that it gets well mixed with the digestive secretions, and consequently more perfectly digested.

5. Cows are far less liable to that complaint known as "dropping after calving," so common in districts where the calf is at once removed from the cow, and less frequent in districts where the calf is left a few days with the cow.

In the case of Jersey cows it is often better to remove the calf at once from the mother, as the milk appears to be too rich, and causes the young animal to scour; consequently it is often found better to mix a little skim milk with the colostrum, for the calf, after the first day.

It must be remembered that the stomach of the calf is not fully developed in the young state; this should be taken into consideration in giving it its food. The newly born calf has only the fourth stomach developed, so, instead of the food going to the paunch, as it would do in the mature animal, it passes directly to the true stomach, which is not very capacious.

It is not uncommon for dairymaids to give the young calf as much as it will drink, feeding only twice daily, instead of oftener with less at a time. This is an exceedingly bad practice, as the walls of the stomach get distended and unable to carry out their functions in a proper manner. The consequence is that the digestive arrangements are upset, and the food improperly digested, often producing either costiveness or scour. For this reason it is important that calves should be fed three times a day for at least three weeks. It is a little more labour than feeding twice, but the benefit that the calf derives will more than compensate for this. It is very important that the milk should always be given at the same temperature. It is a common thing for an impatient dairymaid to give the food before it has had time to cool sufficiently. Numerous cases of scour are known to result from this cause, and the calf may take a fortnight before it returns to its normal condition again; therefore all the food that it gets during this period is consumed at a dead loss, owing to the carelessness of the feeder.

The best temperature to give the milk is about blood heat. Some people prefer to give it a little warmer; it may be just as well, providing it is always given at the same temperature.

When gruels are given they should be prepared from the best forms of food, so that it may contain no admixtures which are injurious to the young calf. Food adulterated with acrid seeds are sometimes the cause of scour. When such is the case it is a good thing to beat an egg up in the milk, together with the smashed shell. One should be given every alternate morning, until two or three are given. Besides curing the scour, the beneficial effects of the eggs will be perceptible in the glossy appearance of the coat.

It may be well here to make a few remarks concerning the **Preparation of the Food for Calves.**

Skim milk should be first raised to nearly boiling point, and allowed to cool down before mixing it with the whole milk. The reason for this heating is to kill any germs that may be in the milk.

Gruels may be prepared by boiling, or by pouring boiling-hot water on to the meal, stirring it, and then allowing it to remain covered to steep for a time, after which it is well stirred again, and when cold enough mixed with the skim milk.

Linseed may be used ground or whole; many people prefer the whole, as it remains in a much sweeter condition than the ground, if kept for any length of time. It should be boiled until it gets into a thin jelly-like condition before being mixed with the milk.

Calves that are inclined to take their food too quickly, should be muzzled, or given a little lump of hay to suck it through.

The muzzles usually consist of a small bucket of leather that just fits over the nose, and can be strapped around the top of the head; a few holes are punched or cut through the bottom, through which the milk is admitted.

There should always be a little of the sweetest meadow hay reserved for the calves; it should be free from dust.

Cotton cake should not be given to calves. Linseed cake, crushed oats, palm-nut cake, Bibby's Calf Meal, and Waterloo Mixed Cake are all suitable foods.

The next point will be **the Summer Management of Calves.**

Some people prefer to keep their calves in a large, loose, well-ventilated house through the summer, with cut fodder, such as grass, clover, vetches, or trifolium, together with about one pound per head per day of cake or meal. This method entails more labour than the turning-out system, but on farms which afford no shelter from rain, or shade from the sun, it is certainly to be recommended.

When calves are intended to be grazed through the summer, they are turned out in May, being brought in at night for a short time at the commencement.

If possible, a few acres of seeds should be reserved for the calves, as they do so much better on this kind of grass than on permanent pasture. The student should bear in mind that newly laid grass is best suited to young cattle and sheep, whilst the older pastures are more fitted for fattening beasts and dairy cows. The calves should continue to get the pound of meal or cake per day whilst on grass, and the younger ones may get an allowance of sweet skim milk.

When calves are turned out on grass in this way they should be setoned. The operation is very simple: it consists of placing a little tape in a seton-needle, and passing it through the skin of the dewlap. A knot must be tied at each end of the tape to prevent its slipping out. This causes slight irritation, and matter or pus is thrown out. The seton should be pulled through every second day or so, to prevent the place healing. The tape is usually dipped in a little blister oil before it is inserted. This setoning is supposed to be a preventative to such diseases as anthrax, quarter-ill, etc., common in well-kept young stock.

This class of stock should always be provided with shelter from both rain and sun; the latter often gets too powerful for them in the middle of the day, and, if no shelter be provided, it acts just as injuriously on these young animals as exposure to rain. In warm summer days, where calves are provided with a shady retreat they will sometimes retire to it as early as nine in the morning, and remain there until three or four in the afternoon. Besides being out of the heat of the sun, they also escape to a large extent the worry of flies.

Calves on grass during summer, under six or seven months old, do not require to be supplied with any water, unless it is a very dry season. This is a point perhaps not very well known: but where the experiment has been tried, some of the calves having free access to water, whilst the others have been kept without any, in all cases those without water kept in the best condition.

The bull calves not intended to be kept for bulls, should be castrated when from three to six weeks old.

The bull calves that are intended to be kept as bulls should be separated from the heifer calves at four or five months old.

After the corn is harvested, it is well to let these calves, or "stirks," as they are sometimes named at this age, run on the young seeds. They are exceedingly fond of this young nutritious grass, and they also find heads of corn amongst the stubble. Care should be taken in putting them on this kind of food at first; they eat so ravenously the first day or so, that they are liable to get blown if left on too long. They should only be allowed on

a few hours at a time for the first four or five days, but when accustomed to the change of food, they may be kept on it without danger.

At this time of the year they will often require to be brought to the yards by night, and in October or November they will usually be brought in on winter fare altogether.

As some of these calves will have been dropped in September and others as late as May, they will vary very much in age.

Before putting them in their winter quarters, they should be separated according to size; if the large and small ones are kept together, the larger ones will take the best of the food, consequently the smaller ones fare badly.

Winter Management of Stock rising One.—If the steers are to be forced for early maturity they should be separated, and given better keep than the heifers; but if not intended for the butcher before they are two and a half or three years old, steers and heifers may be allowed to run together.

After they have been separated they should be placed in open yards with sheds to retire into, or in good roomy well-ventilated houses. These houses are described later on.

In many places in the south of England they have the yearlings house with a small door opening into a sheltered paddock, into which they are allowed to run at will. This keeps these young stirks in a healthy condition; they come out in spring with a good coat, which is often wanting in yearlings that have been kept in the house all the winter. The exercise they get is as good for them as the grass they pick. In the colder climate of the north this practice is not often followed, but they are provided with a good large well-ventilated house, and fed much in the same way as they are in the south.

It is of great importance that young cattle of this age should be well cared for, both as regards food and shelter. It was the practice amongst many farmers some years ago, and is still the practice of a few, to winter this class of stock very badly, simply allowing them to run on bare pastures with next to no shelter, getting straw or a little hay of poor quality, in addition to the little grass they picked. In other cases they might be wintered in yards, on straw and a few turnips. No doubt the practice was supposed to be economical, but in reality it is far from it.

Young cattle wintered under such circumstances will rarely thrive through the winter; in fact, they will often lose flesh, and simply appear like a case of bones covered with a tight hide and a hairy coat. If a few of them happen to be late summer calves, they will not have gained sufficient strength to withstand this meagre treatment, and consequently, on the first appearance of

frost, get an attack of scour, and not unfrequently die from it. In such a case the value of the calf at birth, the value of the food it has consumed, and cost of attendance, etc., has been entirely lost.

But supposing the owner is lucky enough to bring them through the winter without any loss, how much better are these little beasts at the end of the winter than they were at the beginning? They will probably have lost some of their flesh, and perhaps increased a little in their bone, but their constitution will probably be weakened, and they will have less aptitude to grow and fatten than they would under better treatment. Many people would say that they would leave no return for the food consumed, but as this class of stock sell much better in the spring than autumn, they would be more valuable on this account, and would therefore leave a small return for their food; although perhaps not much heavier than they were at the beginning of winter.

We will now consider the feeding of these animals under good management, and then compare the results from a purely economical point of view.

They should be supplied with plenty of good hay and oat straw, a few sliced roots, and from one to two pounds per day of cake and crushed oats mixed. At the beginning of the winter they will get more straw than hay; but the hay may be gradually increased, and straw reduced. The straw they do not consume will go for litter. In some cases this class of stock get very little hay, but receive a little more cake or meal to make up for it.

The amount of roots should be regulated by the appearance of the fæces. If soft, the roots should be reduced; if firm, they may be increased.

In some cases these cattle get their roots boiled and mixed with meal and chaff; it makes a nice food in cold weather; but it is doubtful if the benefit derived is sufficient to cover the expenses of boiling, etc., excepting under very favourable circumstances.

Another common method is to chaff oat sheaves, and mix with pulped roots. In this case they receive no hay or meal, but should always have a little fresh oat straw in their racks.

The amounts of hay, straw, and roots that this class of stock consume vary very much, as the stock themselves differ considerably in age and size. For the sake of the student, it might perhaps be as well to give approximately the amounts they would require.

Roots, from 25 to 35 lbs. per day.
Hay and fresh oat straw, from 7 to 10 lbs. per day.
Cake and meal, from 1 to 2 lbs. per day.
And litter enough to keep them dry.

They might receive their food as follows :—

One pound of cake and meal, and a little fresh hay, the first thing in the morning.

About eight or nine o'clock, half their daily allowance of roots and fresh straw put in their racks.

At eleven o'clock, turned out to drink, and would then return to their straw.

At four o'clock, the remaining half of their roots, and as much fresh hay as they would eat without wasting. In the case of their getting two pounds of cake and meal, the second half should be given mixed with their roots at this meal.

About five or six o'clock their racks should be filled with fresh straw for the night.

By comparing the two systems of keeping these young cattle, it will be seen that the latter and more liberal will prove the more economical. When young cattle are kept under such conditions as those first described, one out of every ten, on an average, would probably go down in the winter, in consequence of being allowed to get low in condition through want of proper shelter and sufficient nutritious food.

To look at the result of turning out in the spring at about thirteen months old; in the first place, there will be ten well-kept yearlings, worth about £7 10*s.* per head; in the second case, nine badly kept, worth perhaps about £5 per head.

The well-kept ones would have had an allowance of cake since about a month old, say, on an average, one pound a head per day; whilst the badly kept ones would have had none. The first-mentioned would also have had an allowance of hay; whilst the others would only have had straw. As regards roots, we will suppose the amount consumed per head to be alike in each case.

If we find the difference in the cost of the keep, and deduct it from the difference in the sale value, we shall get the balance in favour of the well-kept stirks. Supposing the well-kept ones get seven pounds of cake or meal per head per week, for fifty-two weeks it would amount to $3\frac{1}{4}$ cwts. per head, or $32\frac{1}{2}$ cwts. for the ten during fifty-two weeks.

For twenty-eight weeks during the winter we will suppose the best lot to have consumed six pounds of hay and four pounds of straw per day on an average; and the others, ten pounds of straw per day for the same time: reckoning the consuming value of the hay at £3, and straw 30*s.* per ton.

Amount of hay and straw consumed by first lot per head—6 lbs. hay per day = 3 stones per week = $10\frac{1}{2}$ cwts. in 28 weeks. 4 lbs. straw per day = 2 stones per week = 7 cwts. in 28 weeks.

Amount of straw consumed by second lot per head—10 lbs. per day = 5 stones per week = $17\frac{1}{2}$ cwts. in 28 weeks.

Allowing in both cases 28 lbs. of roots per day each, at 10*s*. per ton: amount of roots consumed per head—28 lbs. per day = $1\frac{3}{4}$ cwts. per week = $2\frac{1}{2}$ tons in 28 weeks.

Cost of Food in First Case.

	£	s.	d.
52 weeks' cake and meal for 10 beasts = $32\frac{1}{2}$ cwts. @ 8*s*.	13	0	0
28 „ hay „ 10 „ = $5\frac{1}{4}$ tons @ £3	15	15	0
28 „ straw „ 10 „ = $3\frac{1}{2}$ „ @ 30*s*... ..	5	5	0
28 „ roots „ 10 „ = 25 „ @ 10*s*... ..	12	10	0
	46	10	0

Cost of Food in Second Case.

	£	s.	d.
28 weeks' straw for 9 beasts = 7 tons $17\frac{1}{2}$ cwts. @ 30*s*. per ton ..	11	16	3
28 „ roots „ 9 „ = $22\frac{1}{2}$ tons @ 10*s*. per ton	11	5	0
	23	1	3

	£	s.	d.
Cost of first lot	46	10	0
Cost of second lot	23	1	3
Difference in cost of keep	23	8	9

Value of Both Lots in Spring.

	£	s.	d.
10 well-kept stirks @ £7 10*s*. each	75	0	0
9 badly „ @ £5 each	45	0	0
Difference in sale value	30	0	0

Deduct extra cost from extra sale value to find balance in favour of first lot.

	£	s.	d.
Difference in sale value	30	0	0
Difference in cost of keep	23	8	9
	6	11	3

Balance in favour of well-kept beasts, £6 11*s*. 3*d*., besides the extra value of the manure, in consequence of consuming richer food. The better kept stock would probably do much better than the others in the future.

Spring and Summer Management of Yearlings.—These yearlings will vary in age from twelve to about seventeen months, according to whether they were winter or spring calves.

They are usually run out on grass at the end of April or beginning of May. The time depends much on the following circumstances: the amount of dry food and roots unconsumed,

the forwardness of the grass, and on the state of the weather. They should at first be turned out by day only, brought in by night, and given a little hay and meal, which may be gradually reduced, and discontinued as soon as they are allowed to remain out altogether. This class of stock usually get the run of the second year's grass, or seeds that are not intended for mowing. In the summer they are often put on the aftermath. They should, if possible, be kept in fields that are naturally watered; but in the event of there being no water in the field, they should be taken to some at least twice a day.

In the autumn, when the nights get cold—about October—these animals (now rising two) should be brought in the yards at night, and supplied with roots and fresh straw, so that they may gradually become accustomed to their winter fare.

Some farmers would bull a few of the most forward of these heifers in August; they would then drop their calves about the following May, when they might be two and a half years old; but it is more usual to allow them to pass their second year before bulling, in order that they may get their first calf at three years old.

The oldest of these steers are usually fed and sold fat in the spring, at about two years and a half old, when they should make from forty-six to fifty-six stones dead weight, varying with the breed of beast and kind of feeding. The management of feeding-cattle will be considered later on.

Winter Management of Stock rising Two.—They are usually run out on grass by day until Christmas, and sometimes even later, and brought in by night on straw and roots. The object is to keep them in a good, healthy, growing condition; and if the straw and roots will not do it alone (some straw being much less valuable for feeding purposes than other), they should be supplied with a small allowance of cake or crushed oats.

When not allowed on the pastures, they are best kept in open yards with sheds to retire to at will. They would consume from fourteen to eighteen pounds of straw or rough hay, and from thirty-five to fifty pounds of roots per day; some liberal feeders would give from two to three pounds of cake, though this class of stock, not meant for fattening, usually get no meal. They should have bedding sufficient to keep them dry. In general practice they are usually supplied with more straw than they will consume; what they refuse goes for bedding. They should be allowed to drink twice a day. In some well-arranged buildings they have water always in front of them, so that they may drink at will. The flow of the water in the troughs is regulated by ball taps.

We will consider that we have brought these cattle through

the winter; we now come to the **Spring and Summer Management of these Two-year-olds.** Most of them, by this time, will have commenced their third year. If the grass be considered forward enough in April, they may be turned out by day, and brought in the yards by night; though, if grass be scarce, and dry fodder plentiful, it is better to keep them in the yards until May, so that the grass may get a good start before being stocked.

During the spring the heifers will show signs of wanting the bull. When in this condition, they are said to be bulling. The symptoms are as follows: they get in a very restless condition, and bleat a great deal; they try to mount other cattle, and will stand quiet when mounted by their companions.

If desirable, the heifer should be allowed to have connection with the bull, so that she may get her first calf when she will be about three years old. As before mentioned, in some herds they are allowed to calve at a younger age, often just after they are two years old, the opinion being that the younger a heifer is allowed to calve, the more likely she will be to develop milking qualities. Having to make use of her mammary organs at such an early age, she will have far less chance of developing into a beef-producer. Although, from a dairyman's point of view, the system is good, yet many objections may be raised against it. At this age the heifer will not have developed a well-grown frame; and instead of the nourishment from her food going to build it up, it will be required for the development of the fœtus, and, if she proves to be a deep milker, as required, there will be no chance of obtaining the frame that would be obtained if allowed to go another year before calving. It must also be a great strain on the constitution of a beast to have to maintain a calf before she is well developed herself; so the general opinion is, all things being considered, that a heifer should not be allowed to get her first calf much before she is three years old.

It is generally advisable to bull all heifers that are good enough, the rest being fed for the butcher.

The bulling heifers and steers are usually separated during the summer; and run on grass without any artificial food, generally being kept on the leas or poorer class of pastures. If the pastures are not watered, they should be driven to water twice a day.

If any of these heifers, not good enough to bull, have a tendency to lay on fat rather than grow, which they sometimes have, it will often be advisable to remove them to permanent pasture, and give some artificial food, so as to get them off fat by the end of the summer. They might get some cake during the last two months of their fattening period—from three to four

pounds per head per day. There is usually a ready sale for this class of stock. At the end of the summer they would be from two years and six months to two years and nine months old, and would probably make from £14 to £18 per head. Thinner beasts might be purchased to fill their places at from £10 to £12 each.

Wintering Cattle rising Three Years Old.—They may be divided into two lots, viz. calving heifers, and fattening cattle, the latter consisting of steers, and heifers not in calf; and to these will be added a few of the most forward stock rising two years old.

We will first consider the management of those to be fattened. After running out during summer they should be in a fresh condition. To avoid any loss of flesh they are brought to the yards early (say, in October), before the keep gets too bare and weather too stormy. They will, at first, be brought to the yards by night on fresh straw and turnips, so as to get them gradually accustomed to their winter food; it is a great mistake to change the food of cattle too suddenly. They will soon be taken off the pastures altogether, when they are placed in yards, boxes, or stalls, as the case may be, for the remainder of the fattening season, so that they may be ready for the butcher at about three years old. Some of the most forward of these beasts will usually be pushed on and made fit for the Christmas market, as really good beasts at this season often fetch high prices. They would get rather better food than those to be kept until spring. They would be started on hay and fresh oat straw, roots, and from two to four pounds of cake and meal per day. The straw might be gradually dropped and supplemented by hay, and their cake and meal increased to six to eight pounds per day during the last few weeks of fattening.

The management of the general lot to be sold in spring would be somewhat less liberal. They will probably at first get as much fresh oat straw (barley straw in districts where barley is much grown) as they will eat; from forty to seventy pounds of roots per day—some feeders give much larger quantities of roots than others; and about two pounds of cake and meal per day to each beast. In some cases the meal is not started until later in the fattening period, but it is advisable to give a little to commence with to improve the ratio of the food.

Hay will gradually take the place of the straw, getting at first perhaps only one foddering of hay a day; and soon after Christmas they might get hay by day and straw at night. The straw left unconsumed would be thrown back, for bedding, in the morning.

The cake and meal will also be much increased as the fattening

period extends, and may amount to six to eight pounds per day during the last few weeks of finishing. Some cattle will have a greater tendency to lay on flesh than others, and will therefore be ready to sell first. In dealing with a large lot of cattle it will be seen that some may have a tendency to grow, some to lay on flesh, and some may be much larger consumers than others. They rarely improve uniformly, although they may be bred and fed alike.

These beasts have been traced from calves until they are ready for the butcher at about three years old, when they should weigh from fifty-two to sixty stones (of 14 lbs.) dead weight, according to the quantity and quality of food consumed. This amount of beef at 8*s.* per stone (of 14 lbs.) would be—52 stones at 8*s.* = £20 16*s.*; 60 stones at 8*s.* = £24.

We must now return to the **Winter Management** of the **Calving Heifers.** They may be left out on grass by day much longer than those that are to be fattened, but should be brought to the yards by night. They will get, as a rule, only straw and roots in addition to the grass they pick until Christmas. After this time their food may be improved by the addition of a little hay, or cake and meal.

This class of stock should not be allowed to get too thin, as they have a calf to nourish as well as themselves. They should always have a fair amount of exercise. Yards with sheds to retire into, are the best places to keep them in during the winter when not out at grass, so that they may get plenty of fresh air, and be kept in a good natural healthy condition during their period of gestation.

As the time of calving approaches, their food should be increased, to supply plenty of nourishment for the young calf and also for the production of milk.

Great care should be taken in feeding these animals at this period. They should not have any dusty hay, as it sometimes causes abortion. Cotton cake should not be given to a cow or heifer for a month or six weeks before calving, as it acts injuriously on the system at this period, and is also exceedingly bad for the fœtus.

It is most important that a heifer should not meet with any accident at this stage, as it may cause abortion. If they drop or abort their first calf they will probably be subject to do so throughout their life, which would be a very serious thing. If any accident occurs with a heifer to cause her to abort, it is best not to put her to the bull again, unless she is from a very valuable stock which the owner particularly wishes to breed from. If kept for this reason, she should not be allowed to run with any pregnant animals for the last three or four months of her gestation.

Many farmers keep a goat or a donkey grazing amongst their in-calf heifers. The peculiar smell they give off is supposed by some to be a preventative against abortion.

It must be remembered that it is not safe to bring heifers in too high condition before calving; a good healthy condition without being too fat is best. Fat calving heifers are far more liable to accident during and after parturition than others. They are far more subject to colds and inflammation of the reproductive organs than heifers kept in a natural state.

As soon as a heifer shows signs of approaching parturition, such as the dropping of the pelvic bones and vulva, secretion of milk (shown by the distention of udder and teats), she should be removed to a loose box and made comfortable with a nice bed, so that she may get accustomed to her new abode before calving. She should be closely watched without being disturbed at this period, as she may require assistance in the event of her not being able to expel the calf. It is well to allow her to bring it away without assistance if possible, but if the water-bag, feet, or nose are showing, and she appears to have difficulty in expelling the calf, assistance should at once be rendered.

For the different forms of presentation, etc., the reader may refer to the chapter on "Veterinary Science."

As before described in "Calf-rearing," the calf is sometimes removed at birth. But the teats of a heifer become much softer and better for milking if the calf is allowed to suck them.

It sometimes happens that a heifer is not inclined to lick her calf, but she may be induced to do so by sprinkling some salt and meal over it. After being licked, the calf will soon be able to rise, being at first rather clumsy on its feet; but, in spite of its awkwardness, it will usually very soon find its way to the food that nature has provided, and, after pushing about the teats with its nose for a short time, will manage to catch one between its tongue and upper lip, and will soon show by the waggle of its tail that it knows what is good for itself. In some cases, however, things may not go so swimmingly; the calf may be stupid and require assistance. In this case the mother should be made to stand quietly whilst the calf is put to the udder and induced to take the teat. It is sometimes advisable to open its mouth and milk a little into it, as the taste of the milk will often make it more anxious to get at the teat.

Sometimes the mother, through nervousness, or perhaps being too fond of the calf, will not stand for it to suck, although the calf may be trying hard to do so. Directly it gets at the udder she turns round to lick it; consequently it never gets a chance to secure the teat, unless some one is there to make her stand.

Care should be taken to make the calf suck from all four teats, otherwise the mother may lose a quarter (a teat).

A little milk should be taken off twice a day, by hand, for the first week or so. This leaves plenty of room for the milk secretion to take place freely, and also prevents hard udder.

If the heifer is not required for dairy purposes, but going to be turned into beef after her first calf, instead of weaning the calf at a week or ten days old, it might be allowed to run with its mother about four months, and then weaned. It is a common practice in some districts to let a heifer have one calf to rear during the summer on grass, and then she may be fed during the next winter to a good weight.

It might be well to notice here that, if a cow has twins, which is a common occurrence, and one be a bull, the other a heifer, calf, they should be fed, as neither of them will be safe for breeding purposes. If they are both of one sex they may be kept, as their generative organs in this case will be properly developed. They are known as free-martins in the former case.

We have endeavoured to describe in detail the management of cattle on a mixed farm, containing a fair proportion of arable to pasture land, where the cattle are bred, reared, and fed on the farm, without high-pressure feeding. The stock might be ordinary Shorthorns, or Shorthorns crossed with other breeds.

In order to summarize what has been said, and perhaps make it clearer to the theoretical student, we will suppose that we are tabulating the stock on a mixed farm of from two hundred and eighty to three hundred acres, where from fifteen to twenty dairy cows are kept, twenty calves reared, and about twenty head of home-bred stock (consisting of fat cows, two-and-a-half to three-year-old fat steers, and heifers that have calved or due to calve) are sold every year.

We will consider the number and kind of cattle that would be likely to be on the farm in October :—

Twenty stirks, rising one.	4	9 months old and over, born before December.	
	10	6 ,, ,, ,, April.	
	6	4 ,, ,, ,, June.	
Twenty yearlings, rising two.	4	21 months old and over	To be sold in spring, fat or in calf.
	10	18 ,, ,,	To be wintered, and heifers bulled in spring.
	6	16 ,, ,,	
Twenty two-year-olds, rising three.	10	$2\frac{1}{2}$ years old and over	Ten of these might be fattening cattle and six calving heifers, to calve in spring.
	6	$2\frac{1}{3}$,, ,,	
Twenty cows ..		Sixteen of these would probably be in calf. Four might be dried for fattening. Their place would be supplied in spring by newly calved heifers.	

Besides these cattle, there would, of course, be horses, sheep, and pigs on the farm.

From what has been said, a good general idea of the management of cattle should be obtained; but there are other systems in vogue, which will be described.

The treatment given for heifers will generally be suitable to all systems of farming, varying only in minor points with different stock-owners, farming under varying circumstances.

Early Maturity.—The management of male stock may, however, differ very much, as it has now become a common practice to bring cattle out fit for the butcher from fourteen to twenty-four months old. In order to do this the cattle should be well bred, and from such stock as the Shorthorns or Aberdeen Angus, which have a particular aptitude to come early to maturity.

This practice has many advantages, but still it is not altogether suitable to the farmer with a large proportion of grass land, of a second-class quality, suitable for keeping growing stock, and thus affording them a cheap run through the summer and early part of the winter. It should also be remembered that the labour with cattle on grass would be next to nothing, and no bedding would be required. But, on the other hand, for the farmer with a large proportion of arable to pasture land it is no doubt an excellent system, for the following reasons: (1) The grass land will be reserved simply for the cows and heifers, instead of having the one- and two-year-old steers on it as well, as is the case when they are sold at three years old. (2) It is well known when cattle are well kept the increase in weight per day is greater during the first two years than it is in the third. If this be doubted, the reader may be convinced by looking at the yearly records of the fat stock killed from the Smithfield Show:—

STEERS KILLED FROM SMITHFIELD CATTLE SHOW, 1889.

	Days old.	Live Weight.	Daily Gain.
Not exceeding Two Years Old.			
Hereford	639	1291 lbs.	2·02 lbs.
Aberdeen	709	1757 „	2·38 „
Not exceeding Three Years Old.			
Devon	1000	1744 lbs.	1·74 lbs.
Hereford	1079	2034 „	1·89 „
Aberdeen	1078	2073 „	1·92 „

(3) The amount of carbonaceous matter that would be voided by the animal during the third year, in the process of respiration and oxidation of the tissues, is saved. (4) The animal is never allowed to lose flesh, as is sometimes the case in the other system. (5) It will be put earlier into the market, and therefore make a quicker return for the food consumed.

The objections are: (1) They require more attendance and bedding during summer. (2) Their food must be of a more costly character; only a limited amount of straw can be consumed by this class of stock unless it is steamed, or chaffed and mixed with pulped roots, which adds greatly to the expense. The economy of this feeding will greatly depend on the price of artificial feeding stuffs, as they are used in considerable quantities.

The bringing up the calf has already been described up to the age of three months, when, as a general rule, they are weaned from milk; but when calves are intended to be sold as beef at an early age, it is usual to supply them with a little skim milk and gruel once a day, until they are nine to twelve months old. They are kept in covered yards during the first summer, where they may be supplied with cut grass, clover, vetches, or trifolium, besides some good hay and about two to three pounds of meal and cake per day. If they get no skim milk with gruel of a watery nature, they will require some water twice a day, or in some buildings it will always be in their troughs so that they may drink when they feel inclined.

In the winter they might get a mixture of straw chaff, pulped or sliced roots, meal and cake, perhaps, all mixed up with a little treacle, given three or four times a day, besides getting as much long hay as they could eat; or hay and a little straw, sliced roots, meal and cake given in the ordinary way. Their food would be gradually increased as they got larger. At the end of the first year they might be getting four or five pounds of mixed cake and meal per day, which might gradually be increased to six or seven pounds per day at eighteen to twenty months old, and they would be fit for the butcher between this age and two years old.

We will suppose that we had a calf born in January, 1890, which was sold fat at Christmas, 1891, then 102 weeks old. If we find the value of cake, meal, milk, and gruel consumed, and deduct it from the value of the beef, the balance will be return for hay, straw, roots, grass, etc., consumed.

Cost of Milk and Gruel for Forty Weeks.

		£	s.	d.
First week	6 gallons new milk, at 6*d*.	0	3	0
Second week	10 ,, ,, ,,	0	5	0
Third week	7 ,, ,, ,, 5 ,, skim milk, at 2*d*.	0	4	4
Fourth week	3½ ,, new milk, at 6*d*. 10½ ,, skim milk, at 2*d*.	0	3	6
Eight weeks' skim milk and gruel, at 2*s*. per week		0	16	0
Twenty-eight weeks, half quantity of milk and gruel, at 1*s*. per week		1	8	0
Total cost for 40 weeks		£2	19	10

Amount of Cake and Meal consumed.—First year begin with 7 lbs. per week, and finish with 28 lbs. The animal will begin to get cake and meal at a month old, therefore it gets it forty-eight weeks during the first year.

Average amount per week $\frac{7 + 28}{2} = \frac{35}{2}$ lbs.

$$\frac{35}{\underset{1}{\cancel{2}}} \times \frac{\overset{24}{\cancel{48}}}{1} = 840 \text{ lbs. consumed first year.}$$

Second year begin with 4 lbs., finish with 7 lbs. per day, for 50 weeks.

Average $\frac{4 + 7}{2} = \frac{11}{2}$ lbs. per day.

Average per week $\frac{77}{2} \times \frac{50}{1} = 1925$ lbs. second year.

Total consumed in 102 weeks = 2765 lbs., or 25 cwt.

	£	s.	d.
25 cwts. cake and meal, at 7*s*. per cwt.	8	15	0
Milk and gruel 40 weeks	2	19	10
	£11	14	10

Supposing the beast to have increased at the rate of 13 lbs., living weight, per week, from day of birth, and the carcase weight to have been 62 per cent. of living weight, then 13 lbs. living weight would be equal to about 8 lbs. dead weight.

To find number of stones dead weight—

$$\frac{102 \times \overset{4}{\cancel{8}}}{\underset{7}{\cancel{14}}} = \frac{408}{7} = 58 \text{ stones, } 4 \text{ lbs.}$$

	£	s.	d.
$58\frac{2}{7}$ stones at 7*s*. 9*d*. per stone	22	11	8
Deduct value of cake and milk	11	14	10
	£10	16	10

	£	s.	d.
Return for fodder (cut), hay, straw, and roots	10	16	10

For comparison we will calculate the cost of a beast to be fed at three years old, and compare the balance left in return for grass, hay, straw, and roots. As a calf, it will receive milk for twelve weeks only, at the same rate as the last.

	£	s.	d.
Cost of milk for 12 weeks	1	11	10
First year 1 lb. of cake per day, after 4 weeks old = 48 weeks, 7 lbs. per week = 3 cwt.	1	1	0
Second year, 2 lbs. per day during winter = 3 cwt.	1	1	0
Third year, during fattening, started with 2 lbs. cake per day, finished with 8 lbs.; average quantity, 5 lbs. per day, 35 lbs. per week; 35 lbs. per week for 20 weeks = 6¼ cwt., at 7*s.* ..	2	3	9
Total cost of milk, meal, and cake	£5	17	7

This beast should be about 60 stones; say, at 7*s.* 9*d.* per stone.

	£	s.	d.
60 stones, at 7*s.* 9*d.*	23	5	0
Deduct cost of milk, meal, etc.	5	17	7
	£17	7	5

Return for 3 years' grass, hay, straw, roots, etc., £17 7*s.* 5*d.* or £5 15*s.* 9⅔*d.* per year.

The returns per year would be much alike, rather in favour of the three-year-old beast. No doubt on an average the three-year-old would eat more of these ordinary foods per year than the two-year-old, but it would be of a coarser quality. The dung of the two-year-old would be better in quality, but it would require more litter and a great deal more attendance than the three-year-old. We may conclude from the example that each system has its advantages, and we must not condemn a man who, under certain circumstances, prefers to bring his beasts out at three years old, instead of the more fashionable and earlier age.

Young Bulls for Breeding Purposes are fed very much in the same way as the steers that are meant to be sold at an early age, but sometimes they are allowed to suck the dam.

The System of Buying-in Stock to consume the straw, hay, roots, etc., is adopted by some farmers, especially when they have a large proportion of arable to pasture land. In this case they only rear very few of their own stock, usually keeping a few cows to supply milk for the house, etc.

The kind of stock usually bought are two- to three-year-old Irish or Scotch heifers and steers, also draft cows from dairy districts.

On account of the continual rise and fall in price of fat and lean stock, the system must be considered a risky one. In some years, when lean stock are very high, and the price of fat beef goes back by the time the beasts are ready for the market, the farmer often has very little more than the manure for the food they have consumed; but, on the other hand, if lean cattle are bought in at a reasonable or low price, and beef happens to be high when

they are sold fat, the feeder may get as much as £10 per head for perhaps five or six months' keep.

If the farmer has capital, and is up to his business, by taking one year with another he will make this system pay about as well as any other. But it is not a system that we should recommend a young man to start with, seeing that it would require a man of business, and great experience both in buying and selling.

In buying this class of stock, a farmer would do exceedingly well if, after paying for the artificial food consumed, they left £3 per ton for hay, £1 10*s.* per ton for straw, 8*s.* per ton for roots consumed, and dung over for nothing.

In order to show this we will work out the cost of a fattening animal for twenty weeks. Supposing it to be bought in at £1 10*s.* per cwt., and sold out at £1 17*s.* per cwt., living weight = to about £3 1*s.* per cwt. dead weight, and the animal to have increased at the rate of 14 lbs. living weight per week.

The beast might be 9 cwt. living weight when put up to feed, and started on a ration such as follows:—

56 lbs. of roots
22 lbs. of straw
3 lbs. of cake and meal
6 lbs. of litter
} per day.

The straw would gradually be reduced and replaced by hay; the cake and meal would be increased, and, at the finishing period, the animal might be getting a ration such as the following:—

56 lbs. of roots
16 lbs. of hay
4 lbs. of straw
7 lbs. of cake and meal
6 lbs. of litter
} per day.

We will now take an average ration, and calculate the cost at prices named. The cost will be, per week:—

Per Day.	Per Week.		*s.*	*d.*
56 lbs. roots ..	= $3\frac{1}{2}$ cwts. at 8*s.* per ton	..	1	5
10 lbs. hay ..	= 70 lbs. ,, 60*s.* ,,	..	1	$10\frac{1}{2}$
10 lbs. straw ..	= 70 lbs. ,, 30*s.* ,,	..	0	$11\frac{1}{4}$
5 lbs. cake and meal	= 35 lbs. ,, 70*s.* ,,	..	2	4
6 lbs. litter ..	= 42 lbs. ,, 30*s.* ,,	..	0	$6\frac{3}{4}$
Attendance and interest on capital ..		..	0	$7\frac{1}{2}$
			7	9

	£	*s.*	*d.*		£	*s.*	*d.*
To beast, 9 cwts., at 30*s.*	13	10	0	By $11\frac{1}{2}$ cwts. (living weight), at 37*s.* ..	21	5	6
To 20 weeks keep, at 7*s.* 9*d.*	7	15	0	By manure, 5 tons fresh or 3 tons rotted ..	0	15	0
To balance (in favour) ..	0	15	6				
	£22	0	6		£22	0	6

According to this example, the hay, straw, and roots consumed would be sold at the rate of £3, £1 10*s*., and 8*s*. per ton respectively, and the dung would be left for nothing. But it must be remembered such returns would only be made under very favourable circumstances. In this example the cattle were bought in at 7*s*. per cwt., living weight, less than they were sold at. It often happens that the buyer (when lean cattle are scarce), has to give as much per hundredweight living as he makes of his beasts when they are fat. In such a case a beast weighing 9 cwts. would cost £3 per head more, which would mean £3 off the profit, and consequently less than £3 per ton return for his hay, etc. Besides the question of price, there is always a certain amount of risk to be taken into account. A man in buying a large lot of beasts will often get some that do badly, and would not increase 14 lbs. per week. Also, he might occasionally lose one from accident or disease. This would reduce the profit considerably.

In grazing districts cattle are often bought in the spring, to be fed as soon as there is a good bite for them.

On first-class old pasture land a three-year-old beast may be fed on an acre without the addition of artificial foods, and will lay on from 13 to 15 lbs. of beef in a week, living weight. This would be equal to 8 or 9 lbs. of beef, dead weight. This at 7*d*. per lb. would be equal to 5*s*. per week. The pasture might be grazed by fattening cattle from May until end of August, and after this by lean stock, and perhaps a few sheep to finish with.

Supposing the stock to be bought in at the same price per hundredweight, living weight, as they made when fat—they should make more per hundredweight when fat—the return for such, per acre, might be as follows:—

	£	*s.*	*d.*
16 weeks grazing fat stock, increasing at the rate of 14 lbs., living weight, per week, at 5*s*.	4	0	0
10 weeks grazing lean stock, at 2*s*. per week..	1	0	0
10 weeks grazing sheep, 3 sheep per acre, at 3*d*. per week	0	7	6
	£5	7	6

These first-class pastures that will feed a beast to the acre without artificial food are very limited in area. It may be noticed that the grass is only stocked for thirty-six weeks. This is in order to give it rest after Christmas, so that a good bite may be secured as early in May as possible.

For grazing on second-class pastures, which are much more common, a smaller class of cattle are usually purchased, coming off land inferior, or at any rate not superior, to the land they are to be grazed on. It is usual on this class of land to give an

allowance of cake as soon as the beasts begin to lay on flesh, so that they may be getting cake for about ten weeks before they are sold. From 3 to 5 lbs. per head is the usual quantity of cake given, starting with three and increasing gradually to five pounds per day. The amount of pasture required per beast would vary according to quality, between an acre and an acre and a half, besides the cake. If the beasts put on about a stone living weight per head, per week, on an average, it would be equal to about five shillings per week.

If the cattle were put on in May and sold after sixteen weeks' grazing, allowing on an average $1\frac{1}{4}$ acres per beast, and 28 lbs. of cake per week for 10 weeks, at say 7*s.* 6*d.* per cwt., the return for an acre and a quarter would be as follows:—

	£	*s.*	*d.*
16 weeks grazing fat stock, at 5*s.*	4	0	0
Deduct $2\frac{1}{2}$ cwt. cake, at 7*s.* 6*d.* cwt.	0	18	9
Return for grass eaten by fat beast	3	1	3
10 weeks grazing lean beast, at 2*s.*	1	0	0
9 weeks for 3 sheep, at 3*d.* per week per sheep ..	0	6	9
Return for $1\frac{1}{4}$ acres of grass	£4	8	0

The return per acre would be £3 10*s.* 5*d.* The land might be rented at from £2 to £2 10*s.* per acre, including taxes, and would be gradually improved by the consumption of cake on it. The cake used would be chiefly cotton cake, which has a very high manurial value.

It must be clearly understood that the foregoing figures are only meant to be approximate, and will change with the markets. In ordinary practice, lean cattle should cost several shillings less per hundredweight than fat. Under such circumstances the returns would have been more than stated in the examples taken. Cattle fed on pasture with cake, etc., during summer, should return from twenty to twenty-five shillings per head per month to be profitable.

Cake is never consumed at such an advantage as it is on pasture land. There is far less waste of the manurial constituents, and less labour than when it is given to box- or stall-fed cattle. Instead of the liquid manure finding its way to the drains, as is often the case in yards, the roots of the grass give it very little chance of escape. By its use the beasts are brought earlier to the market, and are made riper in condition, consequently they will fetch a higher price per stone, and die better, than cattle fed on grass alone. More cattle may be fed on the same acreage of land; and lastly, but not least, the pasture itself will rapidly improve in quality and quantity from the

manurial effects of the use of cakes, and by this means land that will carry only at the rate of three-quarters of a beast per acre, may soon be brought by the liberal use of cake, to carry a beast to the acre, or at any rate a very perceptible increased quantity.

It is desirable that all the pasture should not be stocked at once, so that the cattle may be occasionally changed for a week or ten days. By this means the grass will prick up, become fresher, and be more relished by the stock. It is advisable to keep a good bite in a field, as if eaten too barely in a dry summer the grass is less inclined to grow again.

It is not uncommon for cattle to show a preference for certain parts of the pasture, eating these closely and leaving rough patches. If these rough places are cut a little at a time the cattle will clear up this cut grass, after it has been allowed to wither from the effects of the sun, and will also feed on the young grass that appears on the patches afterwards. The rank growths are often caused by the dung of the cattle being left in lumps. In order to prevent this, a boy should be sent on the pasture about once a week to scatter these lumps; this prevents the coarse growths to a great extent.

The third, or poorer classes of pastures are usually devoted to rearing cattle, and the still thinner ones to grazing sheep.

The Herefordshire System of producing Beef is practised in Herefordshire and the neighbouring counties, where there is an extensive area of grazing land. It is the usual practice to allow the cow to calve in early spring; the cow and calf are kept fairly cheaply in the yards, until the pastures afford a good bite, when they are turned out for the summer. During the first few weeks after calving, a little milk is taken off the cow by hand. After that, the calf takes all that the mother provides. Both the mother and the calf lay on flesh very rapidly, being excellent beef-producers. After about seven or eight months the cow dries, and the calf is removed to the house, where it receives hay, straw, a few roots, and a little cake.

The cows live on the pasture until late in the year, in some cases almost all the winter, with the addition of some straw and a few roots. They are provided with a shed for shelter at night. Their hardy constitution seems to make them quite suited to this treatment, and they keep their flesh remarkably well with very little expense through the winter. In the more exposed situations they are brought to the houses or yards for the winter, where they live on straw and roots and a little hay as calving time approaches. After calving their food is a little improved.

The calves, as before mentioned, are wintered on hay, straw, roots, and a little cake and meal, turned out the next summer to

graze, when they sometimes get an allowance of cake, in which case they are sold fat at the end of the summer, about eighteen months old. But it is more usual to graze them at this age without cake, keep them another winter, and then they are sold during their third grazing season, at about two and a half years old, when they make large beasts.

The practice may be suited to certain localities, but cannot be recommended. For supposing the calf at eight months old be worth £9, which would usually be a high price for such a beast, it is plain that it would be the whole return for the year's keep of the cow, and the grass consumed by the calf up to this age.

We will compare this with the return of a dairy cow, which under very favourable circumstances and good management will return in some cases £30 per year—and under ordinary management, selling the milk at 6*d.* per gallon, £16 per year, including value of the calf, this would only be an average return. The labour in the case of the milking cow would be a great deal more than the other system; but taking everything into consideration, there is little doubt, as regards profit, that the ordinary system of dairying could give points to the Herefordshire system of beef-producing under very favourable circumstances.

Under such management as the system described, the inferior milking qualities of the Hereford cattle are not to be wondered at. Turning the cow and calf out for the summer together is not calculated to develop the milking qualities of any cow: if the whole of the milk is not abstracted from the udder, the flow rapidly reduces, this being the case under these circumstances. Then, too, the calves always kept in this fat condition must lose their milking properties, as the collection of fat around their mammary organs is more likely to induce degeneration than development of these parts.

There can be no doubt that the aim of the breeder in the future must be to develop perfection, as near as possible, in both directions; neither the milking nor the beef-producing qualities must be left out of sight, for both are essential. Although these two points are, to a certain extent, adverse to each other, yet we know that they may with judicious selection both be developed in the same animal, for we have good examples in many of our Shorthorn herds. Not only are these excellent beef-producers, but it is a common thing to see them take off the first honours at a dairy show, being perhaps our best-all-round cow; and there is no reason why other breeds, in the course of time, should not be brought to somewhat the same degree of perfection, under the same judicious selection and management.

Although Hereford cows are on the whole poor milkers, it is

not always the case; for we know of a few pedigree cows of this breed that have given fourteen pounds of butter per week each, for several weeks after calving: but these, of course, have been exceptional cases.

Management of Cattle on Clay Land.

Clay land, as a rule, is not suited to the cultivation of roots, but generally grows heavy straw crops. The proportion of roots to straw will therefore be very small as compared with that of an ordinary loam or light-land farm. The question suggests itself: how may the farmer best manage to turn this large amount of dry food and small proportion of roots into beef and manure? Cattle will not consume, or thrive on, an excess of this dry food in its ordinary condition without a mixture of a fair proportion of watery food; so, in some way, it must be made more palatable for them.

Different stock-owners have different ways of obtaining this object. The first and foremost thing is for them to look well after the roots they have at their disposal, and make them go as far as possible. This is usually done by pulping them and then mixing in small quantities with straw chaff and meal: slight fermentation is caused, and the chaff made less rough and more palatable.

This plan is carried out very extensively in Cambridgeshire, where they use very powerful chaff-cutters, which will chaff as fast as an ordinary portable machine will thrash. Their practice is to chaff a certain amount of straw in early summer, mix it with green rye, tares, trifolium, etc., and store it in barns where it is well trodden down, and is used in the following winter. In the autumn, after-math is used for mixing with this chaffed straw, and, in winter, pulped roots are employed.

Fermentation sets in, and causes the chaff to expand and become quite pulpy. In some cases, if packed too tightly, the expansion may be enough to start the walls. Many people consider that the longer it is allowed to ferment, in reason, the better it is; whilst others prefer to use it during the first stages of fermentation, or about twenty-four hours after it has been mixed. When the chaff is very dry it is often advisable to add a little water.

Another method is to mix the chaff and pulped roots in a tank or trough, and to this mixture add soup or thin gruel, made from boiling the allowance of ground cake and meal that the beasts will get; this is poured boiling hot on to the chaff, pressure is put on, and the whole is covered over. The consequence is that the chaff absorbs all this liquid, and becomes very palatable.

When steam power is much used on a large farm, the exhaust steam is utilized by applying it to a mixture of chaff, pulped roots, cake and meal all mixed together in an iron appliance for this purpose. The food thus becomes steamed or cooked, and is made very attractive at little expense.

Another very common way of preparing food, both on clay farms, and on others in spring, when the supply of roots happens to run short, is to mix the food before mentioned in a tank or trough, add water and treacle, and allow to stand for about twelve hours.

When any of these mixtures are used, it is well to add a little salt before giving it to the cattle, unless they are already supplied with rock salt.

Any of these plans are useful for making badly saved hay or straw tasty, which in their ordinary condition might be refused by fattening cattle.

The value of pulping, steaming, or cooking in the ways described is very great in seasons of drought, which cause a failure in the root crop, or in wet harvests when the quality of hay and straw falls below par. Also straw may be much more economically used and made to go further, by this means more of the land may be grazed and the expense of hay-making saved. The cost of preparing these foods will vary very much with different circumstances, being much less when done on a large scale; and costing very little when the exhaust steam of an engine is used. When only a small number of stock are kept, the extra expense of labour will scarcely be returned in beef. If the steam has to be generated for the purpose of cooking the food alone, for a small number of cattle, it would be more advisable to stick to the chaffing, pulping, and fermentation system with the addition of a little salt.

In all cases where these cooked foods are used, long hay or straw should be given with the chop, so as to produce a good flow of saliva, and help digestion generally. Towards the end of the fattening season the supply of uncooked food should be increased, to give the animal a firmer touch.

Duties of the Byreman or Stockman.

The health and well-doing of cattle is greatly dependent on the man who looks after them. If a farmer once gets a good stockman, he should do his best to retain his services. A man who has been on the farm for some time will generally take far more interest in his work than fresh hands. He gets perfectly familiar with the different individual beasts, which is a most

important point. As various beasts often require slightly different treatment, even though they belong to the same herd, a man who is interested in the stock he is feeding, will generally be quick in detecting their different requirements. For instance, if he sees signs of looseness in an animal, he will be careful to reduce the supply of roots, to prevent the approaching scour. A careful eye on such little things may easily turn the balance from unsuccessful to profitable feeding. Another point is, he knows exactly the requirements of his master, and will carry out his orders to the best of his ability.

A stockman should be an early riser, as it is most important that cattle should be fed early in the morning. From 5 to 5.30 is usually considered a very good time for cattle to get their first feed.

They should be fed with great regularity. When they are regularly fed, after consuming their food they lie down to chew their cud, lying quietly until the next meal. If not regularly fed, they will not lie much, but stand restlessly. If the byreman is late in the morning, when he arrives he will find them all up in a restless condition. Cattle never thrive well under such circumstances.

On entering a byre in winter time, it is a good sign to find all the cattle lying quietly, and requiring some amount of stirring to make them rise. They should be disturbed as little as possible by strangers between meals.

Cattle should be kept clean. Their feeding-troughs should always be cleaned out before feeding. They should be provided with a comfortable bed; and, if in a byre, they are better for being mucked out twice a day, although, in many districts, it is only customary to remove the manure every morning.

Cattle that are kept in stalls are sometimes groomed once a day. They keep much cleaner and feed faster when it is done; but the practice of grooming is the exception rather than the rule. When cattle are kept loose in boxes or covered yards, they do without grooming, as they are more at liberty, and get a better chance to lick themselves. The parts they cannot reach may be licked by the companion standing in the same box. Their long rough tongues serve as very good brushes.

The byreman should be careful to give only wholesome food. For instance, such food as dusty hay should only be given when mixed, and cooked or steamed, with other foods. Frosted roots should be placed in cold water, to take out the frost, before being given to the cattle, and should then only be used in small quantities. Cotton cake should only be given in small quantities to young stock; calves under eight months old should get none,

as it has been proved to be an unsuitable food for them. On several occasions calves have been known to die from getting a too liberal supply of cotton cake.

In order to get cattle in a high condition, byremen will often give far too much concentrated food, which in many cases causes derangement of the digestive organs; and, unless these foods are used in moderation, the farmer will not, as a rule, produce his meat at a profit. For these reasons he should be sure that such foods are not given in excess.

Cattle should be supplied with fresh clean water regularly.

If any beast appears to be ailing from any cause, the cattleman should at once report it to his master, so that he may attend to it, or send for professional assistance if required.

With suitable buildings and a mixed stock, some kept in stalls, some in yards, and some in boxes, a man and a boy will look after from sixty to seventy head of cattle. They would be expected to clean and slice the roots, and mix the food themselves; but would have the chaffing and corn-crushing done for them.

If all the cattle were well-grown, they would not be able to attend to so many; or, if most were stall-fed, it would give more work, as the byre would have to be mucked out, whilst the manure is allowed to accumulate in yards and boxes.

Special Remarks on Feeding Cattle.

In choosing a food for cattle the following points should be considered:—(1) The price of the food. (2) Its nature, as to whether it contains any injurious substances which may have a bad effect on the stock. (3) Its digestibility by the stock for which it is required. (4) After the food has satisfied the examiner in these respects, its albuminoid ratio and standard digestible composition should be considered; that is to say, the amount of dry matter, digestible amount of albuminoids, carbohydrates, and fats it contains should be taken into consideration. The ash constituents should be present in large amounts in the food of young stock, to supply the bony and muscular tissues with the necessary amount of phosphates, lime, etc., but need not be present in such large quantities in the case of feeding beasts during the last period of fattening.

The price of the food must be first considered, because it may be at a price which would be impossible to repay by the production of meat. In this case a cheaper food should supply its place. But it must be remembered that many foods have a direct and also an indirect value. The direct value is the

value of the meat it will produce on its own merits, and also the manure value of the food after consumption. The indirect value refers to the good effect it may have in helping to digest, or make more palatable the remainder of the food given in conjunction with it. This is, in many cases, a most important point, and should not be lost sight of.

Some foods have a good analysis, but contain injurious acrid substances, which may have a very bad effect on stock, and should be avoided. Such foods as mustard and rape cake may be taken as examples, although rape cake may be used to advantage sometimes, in small quantities, if boiled or steamed before given to the stock.

Digestibility.—Some foods are much more digestible than others; the most digestible are usually the best to use. The digestibility will vary with the constituents a food contains, or with the mode of manufacture. Some decorticated cotton cakes, for instance, when badly manufactured, contain hard, dark lumps, almost as solid as stone. Such cakes should be avoided, or used with caution, as they can only be partially digested, and will most likely have an injurious effect on the alimentary canal. The best cotton cakes are unsuited for young stock, but prove excellent food for older stock grazing on pastures, or for mixing with other foods for milch cows.

In making up a ration for stock, it is necessary to consider the composition of the foods used before a well-balanced ration can be arranged; so, to do this, we have to refer to tables such as those given by Warington and Lloyd (see next page).

Providing a ration contains the necessary amounts of dry matter, albuminoids, carbohydrates, and fats in proper proportions, the more mixed it is the better, granting, of course, that these mixtures are of good quality and contain no injurious substances.

The first thing a practical farmer has to consider is the nature of the bulk of the food he has at his disposal; that is to say, whether it is high or low in albuminoids. If low, foods rich in these constituents must be added.

For instance, if the bulk of food consists of oat straw and turnips, it would be low in albuminoid matter, and too rich in carbohydrates; so, to balance this, such foods as cotton cake should be added, to bring up the standard of albuminoids.

Before going any further, it might be well to explain in a practical manner what is meant by the albuminoid ratio. We will take the albuminoid ratio of a swede as an example.

It contains water, sugar, starch, digestible fibre, fat, a small amount of nitrogenous matter, and ash.

COMPOSITION OF PRINCIPAL FEEDING STUFFS.

	Dry Matter.	Percentage Digestible.		
		Albuminoids.	Carbohydrates.	Fat.
Barley meal	83·5	8·0	58·9	1·7
Barley straw	81·6	1·3	40·6	0·5
Bean meal	82·4	23·0	50·2	1·4
Brewer's grains	22·2	3·9	10·8	0·8
Cabbage	12·0	1·8	8·2	0·4
Clover, red (silage)	21·6	2·2	11·1	0·6
Clover, red (hay)	78·7	7·0	38·1	1·2
Cotton cake	82·3	17·5	14·9	5·5
Cotton cake decorticated	81·2	31·0	18·3	12·3
Hay (meadow)	79·5	5·4	41·0	1·0
Linseed cakes	79·0	24·8	27·5	8·9
Linseed meal (extracted)	84·0	27·7	34·7	3·2
Maize meal	87·0	9·1	67·1	4·2
Mangels	11·2	1·1	10·0	0·1
Oat straw	81·7	1·4	40·1	0·7
Pea meal	85·1	20·9	55·4	2·8
Rape cake	81·6	25·3	23·8	7·7
Rice meal	79·5	8·6	47·2	8·8
Swedes	12·0	0·8	10·6	0·1
Turnips (white)	7·3	1·1	6·1	0·1
Wheat bran	80·5	12·6	42·7	2·6
Wheat straw	81·1	0·8	35·6	0·4
Wheat	83·6	11·7	64·3	1·2
Barley	83·1	8·0	58·9	1·7
Oats	82·7	9·0	43·3	4·7
Rye	83·7	9·9	65·4	1·6
Maize	83·5	8·4	60·6	4·8
Beans	82·0	23·0	50·2	1·4
Rye bran	83·0	12·2	46·2	3·6
Middlings	83·0	10·8	54·0	2·9

Starch, Sugar, Digestible Fibre.—These are true carbohydrates, and are supposed to be the heat and fat producers, heat being necessary to supply the energy of the animal body.

Fats and Oils.—These are of the same use as carbohydrates, but have the power of producing a much greater amount of heat when oxidized within the tissues.

The heat or energy produced is generally considered to be about two and a half times as much as that produced by the same weight of starch or sugar. The amount above that required for the purpose of producing heat is converted into fatty tissue.

The Nitrogenous Matter is made up of albuminoids (flesh-formers) and amides. All the nitrogenous matter was at one time reckoned as albuminoids, but chemists have found this to be incorrect, as a part of it usually exists in the form of amides. These amides cannot take the place of albuminoids, but may be utilized as heat-producers—so their presence tends to make the ration low in albuminoids.

In calculating the albuminoid ratio of a food, it is necessary to bring the fats and oils to the standard of carbo-hydrates (starches and sugars) by multiplying by 2·5, or more accurately by 2·3, then the ratio of the food will be as the amount of albuminoids is to the amount of carbohydrates, the carbohydrates including the starch, sugar, digestible fibre, plus the fats or oils multiplied by 2·5.

Example: 1000 lbs. of swedes contain about—

Water	893				
Nitrogenous matter	15		Albuminoids	7	
Fat	2	=	Carbohydrates	5	
Soluble carbohydrates	73		,, ,,	73	89
Fibre (digestible) ..	11		,, ,,	11	
Ash	6				

2 of fat = 2 × 2·5 = 5 carbohydrates.
Total = 7 of albuminoids to 89 carbohydrates.
∴ ratio is as 1 is to 12·7.

It would in reality be a little lower than this, on account of the presence of amides not reckoned, as it is only usual to deal with the carbohydrates, fats, and albuminoids.

Cattle that remain at complete rest, simply living without gaining or losing flesh, are supposed to require a ration with an albuminoid ratio of one to twelve; so, in a case of this kind, the swedes might suit the purpose without waste. In the case of animals putting on flesh rapidly, they require a ration with a ratio of one to six or eight. If food were supplied in the form of swedes, in order to get the requisite amount of albuminoids about half the carbohydrates would be wasted. By mixing foods the waste may be avoided, providing we make the ratio of the mixed food to suit the requirements of the animal.

To do this we must add to the swedes a food which is rich in albuminoids, to balance the excess of carbohydrates; they will then be together the required ratio, and in this case no waste will occur.

The economy in mixing foods judiciously may be pointed out, perhaps, more plainly in another way, by taking the standard of food required according to the German tables. According to these tables a fattening beast, a thousand pounds living weight, requires the following quantities of albuminoids, carbohydrates,

and fats: first period, 2·5 lbs. albuminoids, 15 lbs. carbohydrates, 0·5 lbs. fats.

Grass is the natural food of beasts, and a sample of good grass would contain the constituents in these proportions, and from one hundred to one hundred and ten pounds of good grass will supply these quantities stated.

In order to get the required amount of albuminoids from swedes alone, viz. 2·5 lbs., $\frac{2·5}{0·7} = 357$ lbs. of swedes would have to be supplied, as 100 lbs. only supplies 0·7 lbs. This amount of swedes (357 lbs.) would also supply the required amount of fat. But 357 lbs. of swedes would supply $8·4 \times 3·57 = 30$ lbs. of carbohydrates, and as only 15 lbs. are required, there would be a loss of 15 lbs. of carbohydrates daily.

By adding 10 lbs. of decorticated cotton cake to these 357 lbs. of swedes the ration will be much improved, and the waste of carbohydrates will be saved.

Lbs.	Albuminoids.	Carbohydrates.	Fats.
357 swedes	2·5	30	0·7
10 decorticated cotton cake ..	3·0	2	1·2
	5·5	32	1·9

1·9 fat = 1·9 × 2·5 = 4·75 carbohydrates.
= 5·5 of albuminoids to 36·75 of carbohydrates.
∴ ratio = 1 : 6·6.

The above shows how a ration may be improved by the addition of concentrated food. The food in question would be suitable for sheep; but cattle are required to consume hay and straw as well as roots, and, in order to prevent the waste of carbohydrates, concentrated foods, high in albuminoids, have to be added. We will suppose we are feeding with swedes, hay, and straw in the following proportions :—

Lbs.	Dry Matter.	Albuminoids.	Carbohydrates.	Fats.
600 swedes ..	72·0	4·8	63·6	1·2
100 hay ..	79·5	5·4	41·0	1·0
100 oat straw ..	81·7	1·4	40·1	0·7
	233·2	11·6	144·7	2·9

2·9 fat = 7·25 carbohydrates.

Therefore the total = 11·6 albuminoids to 152 carbohydrates, or ratio is as 1 : 13. This is much too low, 1 : 7 being required.

We will see now how the ration would be improved by the addition of 20 lbs. of oats and 40 lbs. of decorticated cotton cake.

Lbs.	Dry Matter.	Albuminoids.	Carbohydrates.	Fats.
600 swedes ..	72·0	4·8	63·6	1·2
100 hay ..	79·5	5·4	41·0	1·0
100 oat straw ..	81·7	1·4	40·1	0·7
40 decort. cotton	32·4	12·4	7·2	4·96
20 crushed oats	16·5	1·8	8·6	0·9
	282·1	25·8	160·5	8·7

Ratio 25·8 to 182·25.
∴ albuminoid ratio = 1 : 7.

The ratio of the above food would be just as required by adding the 40 lbs. of cake and 20 lbs. of crushed oats; and the above amount of food would be sufficient for about ten beasts for one day.

If oat straw were taken as an example of an unsuitable albuminoid ratio, it would show it even more plainly than the swedes. Supposing a beast had to eat enough oat straw to get fat, and to do so it required to get 2·5 lbs. of albuminoids per day, it would have to consume 180 lbs. of straw daily to get this amount of albuminoids, and would get 72 lbs. of carbohydrates and 1·2 lbs. of fat, = to 3 lbs. more carbohydrates.

Therefore the ratio would be 2·5 to 75; this would mean a waste of 60 lbs. of carbohydrates per day. But we know quite well that a beast would not get fat on oat straw alone, neither could it consume or digest 180 lbs. per day if it tried.

We will now see how much it would require to consume in order to exist, without putting on flesh or losing weight. According to the tables it would require sufficient to supply 0·7 albuminoids, 8 lbs. carbohydrates, 0·15 of fats.

	Albuminoids.	Carbohydrates.	Fats.
100 lbs. of oat straw contain	1·4	40	0·7

To supply 0·7 of albuminoids 50 lbs. of oat straw would be needed; this amount would supply 12 lbs. of carbohydrates and 0·2 lbs. of fat more than required, therefore wasted.

Suppose we replace half the straw bv 45 lbs. of roots, and see what we get.

Lbs.	Albuminoids.	Carbohydrates.	Fats.
25 straw ..	0·35	10·0	0·17
45 roots ..	0·36	4·5	0·04
	0·71	14·5	0·21

By replacing part of the straw by swedes the ration is much improved, as it saves half the waste of carbohydrates.

We will suppose in the above case that oat straw is selling at 35*s.* per ton and swedes at 8*s.* 4*d.* Then 50 lbs. of oat straw in the first case would cost—

$$\frac{5\cancel{0}\times 35\times 12}{224\cancel{0}}=\frac{2100}{224}=9{\cdot}4d.$$

1st ration: 50 lbs. of straw daily, costs 9·4*d.*

		d.
2nd ration:	25 lbs. of oat straw, at 35*s.* 0*d.* per ton ..	4·7
	45 lbs. of swedes at 8*s.* 4*d.* ,, ,, ..	2·0
		6·7

By supplying the 45 lbs. of roots instead of 25 lbs. of oat straw there will be a saving of 2·7*d.* per day on the maintenance diet of one beast.

We will calculate in the same way the amount that may be saved in the case of a fattening beast. Supposing it obtained the required amount of the different constituents from straw, it would consume 180 lbs.

$$\frac{\overset{9}{\cancel{180}}\times\overset{5}{\cancel{35}}\times\overset{3}{\cancel{12}}}{\begin{array}{c}\cancel{2240}\\ \cancel{112}\\ \cancel{16}\\ 4\end{array}}=\frac{135}{4}=33\tfrac{3}{4}d.$$

The daily ration in this case would cost $33\frac{3}{4}$*d.*; but by supplying a certain amount of roots in the place of some of the straw the cost will be much reduced.

We will supply the place of 120 lbs. of straw by 200 lbs. of roots.

Lbs.	Albuminoids.	Carbohydrates.	Fats.
60 straw ..	0·84	24	0·42
200 roots ..	1·60	21	0·20
	2·44	45	0·62

To get the requisite amount of albuminoids it takes the above ration; but there is a great waste in carbohydrates, and costs—

		$d.$
60 lbs. of straw,	at 35s. 0d. per ton ..	$11\frac{1}{4}$
200 lbs. of swedes,	at 8s. 4d. ,, ,, ..	9
		$20\frac{1}{4}$

So it appears, by supplying the roots in the place of some of the straw, a gain of $13\frac{1}{2}d$. per day is made.

By reducing the swedes and straw, and adding a little cotton cake, the cost may still be reduced, and the animal will be supplied with the necessary constituents.

Lbs.	Albuminoids.	Carbohydrates.	Fats.
75 swedes ..	0·6	7·8	0·075
20 straw ..	0·28	8·0	0·14
5 cotton cake	1·55	0·95	0·6
	2·43	16·75	0·815

		$d.$
75 lbs. swedes,	at 8s. 4d. per ton ..	$3\frac{1}{2}$
20 lbs. straw,	,, 35s. 0d. ,, ,, ..	$3\frac{3}{4}$
5 lbs. cotton cake,	,, 80s. 0d. ,, ,, ..	$4\frac{1}{2}$
		$11\frac{3}{4}$

Saved by addition of cotton cake, per day, $8\frac{1}{2}d$.

The above ration would be improved by using a greater variety of foods, but for our purpose of showing the economy of a well-balanced ration it does quite well, and works out very near to the required amounts; viz. 2·5 albuminoids, 15 carbohydrates, 0·5 of fat.

It should be clearly understood that the examples taken are only meant to be theoretical. In practice it would be impossible for a beast to consume some of the amounts given. It would also greatly depend on the quality of the food as to whether the animal made any progress or not.

From the foregoing remarks and calculations, the importance of thoroughly understanding the albuminoid ratio and how to put it into practice in making up a ration may be easily seen. It has been plainly shown that a great deal of money may be saved in feeding a number of cattle, by selecting proper foods, and mixing them in proper proportions, so as to make a well-balanced ration.

Amount of Water in a Food.—It is usually considered that a

beast requires about four times as much water in its food as dry matter, and a sheep twice as much; consequently, all they receive above this amount causes a needless waste of energy in heating this extra amount up to the temperature of the body, about 100° F. To produce this extra amount of heat the oxidation of a certain amount of carbon within the tissues will be required, and the food supplying it will be wasted.

To take an example to explain the above, we will suppose sheep to be feeding on *roots* containing 90 per cent. of water. So, then, a sheep in consuming one hundred pounds of roots would consume only ten pounds of dry matter to ninety pounds of water. If the theory be correct that it requires only twice as much water as dry matter, it would need only twenty pounds, and, consequently, will have consumed seventy pounds of water more than necessary. It would require about 2450 units of heat to raise this amount of water to the temperature of the body; this would need the combustion of as much carbon as would be in eight pounds of roots, consequently there would be a waste of 8 per cent. of the roots in heating the extra amount of water.

It is rather doubtful as to whether this theory is to be taken as being strictly correct; it will, of course, depend on the temperature that the cattle or sheep are subjected to. For instance, grass contains about 80 per cent. of water, 20 per cent. of dry matter, just four times as much water as dry matter, or twice the quantity theory states to be required by sheep; and yet sheep do well on it, and in warm weather will drink as well. Cattle on grass require to be supplied with water; it would therefore appear that they require more than four times as much water as dry matter: and although sheep require less water in proportion than cattle, they probably require three or four times as much water as dry matter; otherwise, when kept entirely on roots which contain nine times as much water as dry matter, the result would not be so satisfactory as it usually is.

But leaving the exact quantity of water they require in proportion to dry matter out of the question, the example worked out serves to show that there must necessarily be a very considerable amount of waste of carbohydrates, occasioned by using a food containing an unnecessary amount of water. In feeding, this factor must always be taken into consideration.

In addition to the waste of carbohydrates, there are other reasons why the amount of water should not be too high. In winter time, when the temperature is very low, these succulent foods containing high percentages of water are affected by the temperature of the atmosphere more readily than drier foods, such

as hay or straw, so therefore fall below them in temperature. Sheep or cattle will consume them more readily than drier foods; in fact, cattle will often take six times the weight of roots as they will of hay and straw, and consequently would have all this weight of cold food in their stomachs at once. In consequence of the hay or straw being digested much slower it gets heated by the process of mastication, and rises in temperature by the time it reaches the stomach.

If an animal has to live on cold watery roots during winter, it may reasonably be expected that they may act prejudicially, and cause derangements in the digestive system. In extreme cases such feeding may result in disease, more or less fatal, such as hoven, braxy, inflammation, colic, scour, stoppage of the water, etc., all these being common ailments amongst sheep or cattle receiving large quantities of roots.

Mixing Food.—Providing all foods given are sound and they are given in quantities so as to make a well-balanced ration, the more mixed they are the better, as cattle eat them with more relish; they also get a better chance of being digested than when a fewer number of foods are given in larger proportions. It is a good thing to change the food occasionally, but this should only be done very gradually, as too sudden a change often causes indigestion, which may cause the animal to lose flesh.

In spring time, when such foods as green rye, vetches, clover, or trifolium are obtainable, they should be given only in small quantities at first, chaffed or mixed with straw or hay, until the animals get well accustomed to their new diet.

Vetches are very succulent, and are eaten in a fresh condition very ravenously by cattle. In the event of their being allowed to have too much, they will be very likely to suffer from blown or hoven.

Foods of this kind should always be cut some hours before they are given to the cattle. Those cut in the morning should be given at night, and those cut at night given the next morning.

Brewers' Grains contain a high percentage of water, and are good for producing a large flow of milk. They should be kept well pressed together, with an occasional sprinkling of salt, and well covered to prevent their coming in contact with the atmosphere—otherwise they will soon become sour, and be injurious to stock.

Cakes.—All cakes should be kept in a dry place. Linseed and such-like cakes should be packed in layers at right angles to each other, to admit the air between; this prevents them from becoming mouldy. Mouldy cakes should not be used for feeding; they are often very dangerous, sometimes causing blood-poisoning and such diseases as anthrax.

Decorticated Cotton Cake is a good food for mixing with others for cattle in winter, and about the best concentrated food to give to cattle on grass. It neutralizes the purgative action of the grass; it is very high in albuminoids, and contains a higher manurial value than any other food. It is also an excellent food to mix in a ration for a milking cow, but it should not be given too near her calving period, either before or after. Neither should it be given to stock under one year old, unless in very small quantities mixed with other foods of a more carbonaceous nature. The reason for this food being so unsuited to young stock seems rather difficult to explain, but it has lately been considered that its highly nitrogenous nature acts prejudicially on the liver.

Many of these cakes, when badly manufactured, contain hard indigestible lumps, and should be used with caution.

Undecorticated Cotton Cake is less valuable than the decorticated, and can only be recommended for cattle out at grass, though it is often used for mixing with other foods for cattle in the winter. Taking its feeding and manurial value together, it is worth from 56*s*. to 60*s*. per ton less than decorticated cake.

Linseed Cake is a good food for calves and all feeding stock, but it is not suited to milking cows, as it imparts a bad flavour to the milk.

Palm-nut and Cocoa-nut Cakes are good for milking-cows.

Rape Cake is considered by some people a good food for milking cows; it imparts a nice flavour to the butter, but should be used with caution, as it often contains impurities and acrid juices. Its use may be made safe by boiling or steaming it, as this seems to have the effect of destroying the injurious action of the juices. Rape cake is sometimes used as a manure.

Bean Meal is a food very high in albuminoids, and is much valued by the Scotch dairy farmers, as a food for cows. It is also very suitable for mixing with other foods for fattening cattle. It has the effect of making the flesh hard, so therefore should not be used too heavily towards the last period of fattening. Beans are particularly good for giving to male animals during copulation.

Maize is a food rich in carbonaceous matter, and good for mixing with other foods for fattening stock; but it produces meat of a yellow oily character, so therefore should not be used too heavily in the finishing period. Owing to its being so low in lime and ash constituents, it is not a suitable food for young stock. It was found at Rothamstead that a mixture of a little superphosphate, to supply the ash constituents, improved the feeding properties when given to pigs.

Bran is a nitrogenous food, and good for the purpose of

mixing with other foods. It is particularly good for milking-cows, and makes good mashes for all kinds of stock.

Oats are used for all kinds of stock, more particularly for horses.

Barley is not so generally used for feeding purposes as oats, but makes the best food for pigs. It may be given either ground, boiled, or grittled.

Coamings consist of the little rootlets taken off from malted barley. They make a good food for stock—best known in the neighbourhood of distilleries.

Treacle is often used for feeding purposes, mixed with chaff and mashes. It imparts a nice flavour to the food, and cattle eat it very readily; it is also valuable for the amount of soluble carbohydrates it contains.

Fenugreek is also used to flavour foods, and is supposed to be very good for horses.

Salt should generally be within the reach of all animals (except those that are far advanced in pregnancy). It keeps them in good health, and also improves the appetite.

On the Modes of Housing Cattle.

When cattle are exposed to cold wind and rain they will not put on flesh as rapidly, with the same food, as if they are comfortably housed.

Cattle in exposed positions during winter require a liberal allowance of good food to increase their flesh at all; it is far more common to see them lose weight, and thus the food they consume is lost.

The economical reasons for good shelter may be summed up as follows:—Firstly, the cattle, instead of being restive, are comfortable and lie contentedly, which is conducive to laying on flesh. Secondly, less food is required to keep up the heat of the animal body than when exposed to low temperatures. About 60° F. is the best temperature for cattle-houses during winter. The normal temperature of the animal body is about 100° F., so that enough food has to be consumed to raise the body 40° F. higher than the house. But if the beast be exposed to a temperature of, say, 40° F., it will require half as much food again to supply the heat of the body; as cattle lying out are often exposed to lower temperatures than this, they will require proportionately more food for the production of heat.

From the above remarks it might appear economical to house cattle at a higher temperature than 60° F. to economize the heat-producing foods; but this is not the case, as when animals

are kept in houses where the temperature is too high, they become very uneasy and restless on this account. A higher temperature is also injurious to the health of the animals. So, all things considered, about 60° F. is the temperature that gives the most satisfactory results.

Cattle used for breeding purposes should never be kept at higher temperatures, although they sometimes are, the result being, in many cases amongst our highly bred stock, degeneration of the development of the lungs. To prevent this, young breeding animals should have access to plenty of fresh air and a fair amount of exercise.

Yards and Covered Sheds usually consist of one long-roofed building walled at the back and ends; the ends are extended to form the yard. The whole building is separated by walls parallel to the ends, to form the series of sheds and yards; instead of masonry, these partitions are sometimes erected from old railway sleepers.

With the exception of pillars of granite, masonry, or wood for the support of the roof, the front is perfectly open to the yards. There should be a gate to each yard large enough to admit a cart, for clearing out the dung. On account of the accumulation of dung in the yards, the gate should be made to open outwards.

The water and root troughs are usually placed by the sides of the walls in the yards, whilst the cake troughs and hay and straw racks are placed in the sheds, though the yard troughs are often used for both roots and cake.

These yards and sheds are very useful in sheltered positions, especially for young growing stock—or feeding-cattle of a hardy nature. As several beasts are turned into these yards together, polled animals are most desirable when this system of sheltering is pursued.

In this system plenty of litter is required, so it can only be recommended in districts where straw is plentiful.

These yards and sheds are made of various sizes, according to the number of cattle they are meant to hold; the yard is usually two or three times the size of the shed.

The roof should be well spouted to prevent too much water falling on the manure.

Hammels consist of a long building, subdivided into boxes with a little yard outside each box, forming a row the whole length of the building. The system of buildings differs from the last described, in that there is a wall in front instead of pillars, and that the compartments and yards are much smaller, being generally calculated to hold two animals, and never more than three or four.

The doorway should be built fairly high, to allow for accumulation of manure. The coignes should be rounded, as cattle are then less liable to injury whilst passing from the shed to the yard, or *vice versâ.*

The racks should be movable, so that they may be raised as the manure accumulates.

In this system the beasts get fresh air and a little exercise when they please, with the box to retire to when they prefer to do so.

A suitable size for two or three beasts would be about 16 feet by 12 feet for the shed, and the yard a little larger. The roof should be spouted.

Covered Yards.—This system resembles the first in that several beasts may be turned loosely in together, polled animals being the most suitable. This system is practised extensively in some parts of Scotland, where polled cattle are kept.

The covered yards are situated near the byres, and the partially made dung is in some cases removed from the byres to the yards, to be made into better quality manure.

The advantages that this system has over the first mentioned are that less litter is required, and the manure is preserved from the washing rain, and is consequently much more valuable. Although the buildings cost more to erect, it is considered that the saving of litter and extra quality of the manure will compensate for the extra outlay.

These yards are made of various dimensions, but as a rule about eighty square feet is allowed for each beast.

Boxes differ from covered yards in that they are much smaller, generally being built for the accommodation of one or two animals, with a hay-rack and feeding-trough inside. It is usual to have a hole in the wall with a shutter for the purpose of putting the food into the rack or trough without entering the box, excepting for the purpose of cleaning the trough or bedding the beasts. They have all the advantages of the covered yards as regards manure and litter; and as they only contain one or two beasts, it enables the farmer to separate the more brutal animals from the weaker ones, which in the large covered yard system have often to run together, in which case the stronger beasts drive the weaker ones from the best of the food until they have first satisfied their own appetites.

The floor of the boxes is often sunk below the level of the outside to prevent any of the liquid manure draining off; it is consequently absorbed by the litter. As the animals are not tied they have the advantage of getting a little exercise. The solid and liquid manure and litter get well mixed up together, and may be carted off at intervals when required.

The usual area allowed per beast in a box may be taken at about ninety square feet.

Stalls, byres, shippons, and **cattle-houses** may be taken as all meaning the same, simply being different names given in different localities to the same class of cattle-buildings for the accommodation of mature stock during winter.

The byre is usually a long building containing two rows of stalls, with a passage between running its full length.

The stalls are divided by a low wooden partition, so as to allow room for two beasts to stand side by side in each. Along the head of the stall one long or two short troughs are placed in front of the animal, and occasionally a hay-rack; it is more common to have no rack, the hay or straw being thrown between or on the troughs. To a strong upright post on either side of the stall there is a long staple fixed for the purpose of carrying a chain, which slides freely up and down, and by which the beast is chained round the neck to the stall. The chain is either fastened by a crook and link, or a dog and ring.

The stalls are arranged on a slightly raised platform, which slopes very gently towards the gutter at the back of the stall. The gutter should not be more than about six inches deep, though they sometimes are much more. Cows heavy in calf are liable to slip suddenly from the stall to the gutter, and may injure themselves when the curb of the gutter is too high.

Double byres are arranged as follows. The fronts of the stalls face each other, with a feeding passage between, on which rails are laid the whole length of the building. A feeding-truck runs on these rails from a house or compartment at one end of the byre, in which the food is prepared for the stock. This arrangement for feeding is very convenient. Some people object to this system, on account of the dung not falling in one passage, and having, consequently, to be put in two dung-pits; but this inconvenience may be avoided by having small doors through which the dung may be removed at the end of the byre opposite the food-mixing house.

The byres more commonly met with are arranged rather differently. The heads of each row of stalls face the walls on either side of the building, and the cows' tails face the passage between. In this case all the dung falls into one passage, and is better for cleaning out than the other system, but the feeding arrangements are not nearly so convenient, as the cattle-man has to walk up between the two beasts to feed them.

The dimensions of such a building may be as follows: Width of passage from curb to curb, about seven feet; length of stall, about seven feet—about fifteen inches of this would be taken up

by the feeding-trough, which is raised a little above the level of the stall;—width of the stalls, about seven feet.

The passage is raised in the middle, and slopes each side towards the gutter. The heel post of the partition separating the stalls is usually about two and a half feet from the curb.

Another plan of building, seen on small holdings more particularly, is to have a single row of stalls, with a feeding-passage in front. The stalls are of about the same dimensions as those described, and the passage behind is usually about four feet.

Less litter and less space are required per beast in the stall system than in the box, but the labour of cleaning out the dung once or twice a day is much more than in the box system, where it is allowed to accumulate and absorb the liquid manure, and may only be cleaned out when it is required to go straight to the land. This saves the labour of putting it into a midden to rot, and unless there is a covered manure-pit, the quality of the byre manure is inferior to that made in the boxes. It is exposed to all the rain that falls on the midden, which dissolves and washes away much of the soluble and valuable constituents.

It is convenient if all these buildings can be supplied with fresh water from a cistern, by means of pipes and taps, so that water may always be in front of the animals. In this case the troughs should have a plug at the bottom, to clean out the water if required.

Troughs are made of earthenware, stone, cement, slates, and sometimes iron, but the first mentioned are easiest to keep clean.

Cattle houses should always be well ventilated, but draughts are to be avoided.

C.—*The Breeds of Sheep found on the British Isles.*

These breeds may be conveniently divided into three classes, viz. Longwools, Shortwools, and Mountain or Upland Breeds.

The **Longwools** consist of the Leicesters, Border Leicesters, Lincolns, Cotswolds, Romney Marsh, Devon Longwools, South Hams.

The **Shortwools** include the South Downs, Shropshire Downs, Hampshire Downs, Oxford Downs, Suffolk Downs.

Mountain and Upland Breeds consist of Cheviots, Blackfaced Scotch, Herdwicks, Lonks, Exmoor, Welsh Mountain.

Other Breeds—Dorset Horns, Dartmoor, and Ryeland.

The **Leicesters** some years ago were considered our most important breed. The original type was a large, coarse-boned, rather ungainly animal, generally spoken of as "Old Leicesters." Robert Bakewell, of Dishley, spent a great deal of time and

care in improving this breed of sheep, with great success; since about the year 1760 this improved breed took the name of the "New Leicesters." Pure Leicesters of the present day vary a little in type, some being much larger than others, and varying with the different ideas of perfection brought out by continual selection by their numerous breeders. They may be described generally as a fairly long-woolled, white breed, with a broad, straight, and flat back, generally much wider in the middle than at the shoulders or rump, with a short neck, tapering towards the head. The head is well set on, long thin ears set widely apart, with a full eye and pleasant countenance. The rump is rather narrow, but a good height above the tail; a deep full chest, standing near the ground. The skin is thin and supple; the wool is fine and fairly long, but many of this breed lose wool from their neck, belly, and back at an early age. They are often poor nurses.

They have a great aptitude to fatten, and come early to maturity. Notwithstanding their small percentage of offal to carcase weight, they have long since gone out of date as butchers' sheep, for they carry too large a proportion of fat to lean meat.

No other breed of sheep has been used with such success for crossing and improving other breeds as the Leicesters. In fact, the Leicester blood has been introduced some time or other into almost all other breeds, with the desired effect of improving them. To some it has imparted constitution, and to others aptitude to fatten and to come early to maturity.

The dead weight of an ordinary Leicester may be taken from twenty to twenty-four pounds per quarter, and the fleece from eight to nine pounds.

The **Blue Leicester**, or *Wensleydale*, is a large variety of Leicester found chiefly on the Yorkshire wolds. They have a bluish skin and darker appearance than ordinary Leicesters. They are larger, longer in neck, coarser in their bone and wool, with less aptitude for laying on fat and coming early to maturity, and do not possess the excellent symmetry of the ordinary Leicester.

The rams are much used and liked by the Scotchman for crossing with their Blackfaced mountain breed. They like them as dark as they can be bred, as the darker they are the larger will be the percentage of blackfaced lambs dropped. This is a matter of importance, as butchers always prefer the black faces to the white.

The **Border Leicesters** have for many years been quite a separate breed from the ordinary Leicester, although they were originally got from Bakewell's stock. In the year 1767, Messrs. George and Matthew Culley, who had been pupils of Bakewell,

left him, and went to the Border, taking with them a flock of Dishley Leicesters. They were soon afterwards followed by Mr. Robert Thompson, another of Bakewell's pupils, who also established a Dishley flock at Lilburn, and then at Chillingham Barns. The merits of the sheep soon became recognized, and other flocks were started.

The change of soil and climate naturally altered the characteristic points of the Dishley Leicesters, and this, combined with selection and breeding for certain lines, soon gave the Border Leicesters a particular type of their own; as the English Leicesters were very closely in-bred in order to secure higher quality, they slightly degenerated in size: hence it was, as generation followed generation, the types of these two breeds, though of the same origin, became wider and more distinct.

FIG. 82.—Border Leicester ram; property of J. Twentyman, Esq., Hawkrigg, Wigton.

Some writers consider that the Leicesters taken to the Border were crossed with the Cheviot breed, and their whiter colour than the Dishley sheep was the result of this cross. This, however, is unlikely, for the following reasons—firstly, the Dishley breed at that time was whiter than the Cheviot—it was quite common fifty or sixty years ago to see Cheviots with brownish faces and legs;—secondly, this cross would tend to lessen their size, whilst they are larger than the original breed; thirdly, the Cheviot has a deep and round belly, whilst the Border Leicester is even more drawn up and less inclined to have a round belly than the Dishley Leicesters.

They are big stately sheep, with good length, and clean white faces and legs. A well-bred one should possess the following points: The head of fair size and profile slightly aquiline, tapering to the muzzle with fairly wide nostrils; a full bright eye; ears of fair size and well set; neck strong and tapering towards the head, which stands up higher than that of the ordinary Leicester; the chest broad, deep, and descending perpendicularly from the neck, but appearing to come even forward in the unclipped sheep; the shoulders broad but not coarse; from the front of the withers to the rump should describe a perfectly straight line; the rump is well developed; the ribs well sprung from back-bone, giving a broad back; the belly straight and fairly flat, significant of small

offal; the legs straight with fair amount of bone, clean and fine; no signs of wool should be seen on the head, or on the legs below the knees or hocks; the head, ears and legs should be of a uniform white colour; on both arms and thighs the flesh is well let down to the knees and hocks; the body is more distinguished by its width than depth, showing a tendency to carry its mutton high. They should be well covered with wool of medium texture and open "pirl" towards the ends; but they often fail in this respect, some having a tendency to lose their belly wool.

Average dead weight when fat, twenty-three to twenty-six pounds per quarter; average weight of fleece about ten pounds.

The rams of this breed are sold in great numbers in the South of Scotland every year, where they fetch very high prices. They are used for crossing with the Cheviot and Blackface ewes; they make very valuable crosses with either, which are much esteemed by the North of England and Lowland Scotch farmers. Many thousands of these cross-bred lambs are brought across the border every year, and folded on roots during the winter, from which they are sold fat.

The **Lincolns** may be described as the finest of all the long-woolled breeds; although they are perhaps no larger than the Cotswold, they are superior as regards both quality of flesh and wool.

The old-established breed of more than a century ago was larger, and much coarser, with less aptitude to fatten, than the breed of the present day. The rams had deeply wrinkled faces, traces of which may often be seen amongst the old rams of the breed now existing. In Bakewell's time there was a great rivalry between the Leicester and the Lincoln breeders, consequently Leicesters were kept out of Lincolnshire as much as possible. As time went on, the merits of the Leicesters became so apparent with some farmers as to overcome their prejudice, and by this means the Leicesters began to expel the Lincolns from the poorer class of soil in their own county, until it was only on the stronger and better classes of land that the Lincolns remained. The Lincoln breeder, though perhaps unwillingly, was obliged to acknowledge that a little of the Leicester blood might be introduced into their breed with advantage, and those breeders who used it did so with great advantage to their flocks. The result was a slightly diminished size and amount of wool, improved symmetry, better quality flesh, with a greater aptitude to fatten, and at the same time sheep better suited to the poorer pastures than the Old Lincolns.

After the Leicester blood was introduced, the Lincolns rapidly improved, lost their coarseness, and acquired the good

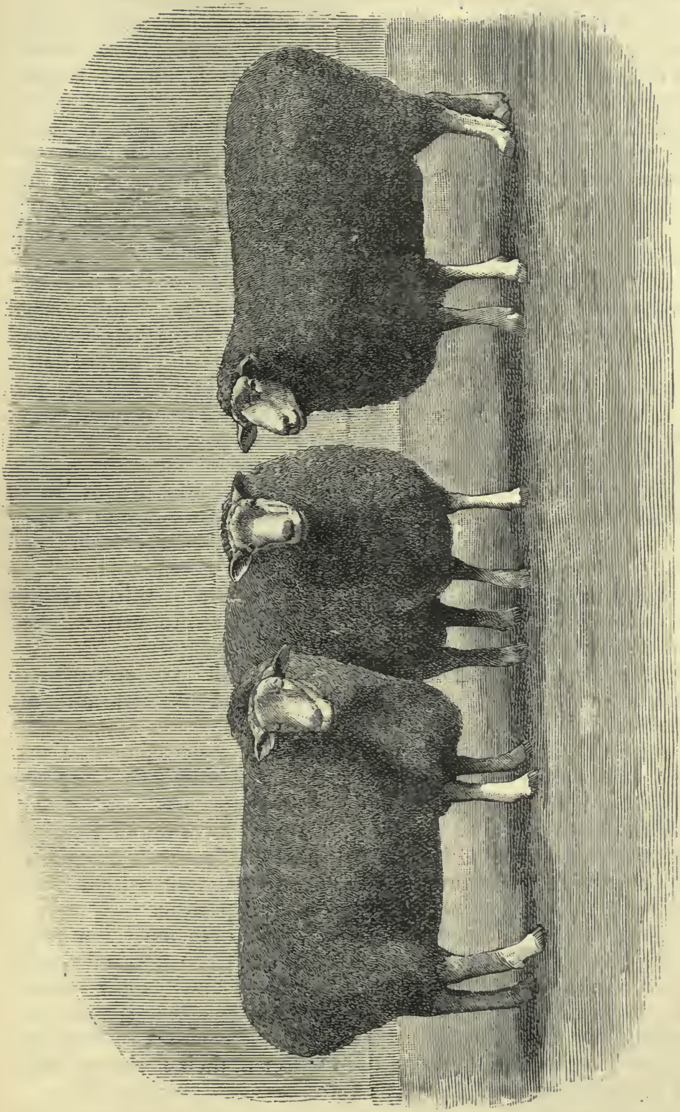


FIG. 83.—Lincoln shearlings.

points of the Leicesters, and were superior to them in size. The result of this change was seen, not only in Lincolnshire, but also in the neighbouring counties, where the Lincolns turned the tables on the Leicesters and became the favourites, excepting on some of the poorer classes of land which were not calculated to carry such a large breed with a heavy fleece. Since then the Lincolns have been the prevailing breed in their own county, and also on the better class of land of the neighbouring counties. Since about the year 1850, this breed has come into great repute. Great numbers have been exported at very high prices. At the Windsor Show (1889), three Lincolns were sold for five hundred guineas.

Description.—A large whitefaced breed with a small tuft of wool on their head—sometimes with a few black spots on their ears and face; thick strong neck, broad shoulders and good back; occasionally they have a tendency to be high in the withers and slack behind the shoulder, but with good breeding this disappears; they possess strong bone, and their wool surpasses that of all other British sheep in quantity, besides being of excellent quality.

Their mutton is very superior, having a good proportion of lean to fat meat, but usually too large for most markets. They are, like the Border Leicesters, very much used for crossing and improving the size of other breeds.

Their average dead weight is from twenty to thirty pounds per quarter. Some rams of this breed are said to have weighed over ninety pounds per quarter, dead weight.

When kept on good land their fleeces will average twelve to fourteen pounds each. They make excellent mothers, and are fairly prolific, but not suited to poor land.

A peculiarity about this breed is, that they occasionally throw black lambs; these are seldom seen in a breeder's flock, as they are usually killed by the shepherd.

The **Cotswolds** are a breed of sheep that have for vast periods been natives of the Cotswold Hills in Gloucestershire. They are remarkable for combining a massive frame with a constitution adapted to upland grazing on short pasture.

They have generally white faces, but occasionally mottled or grey, with legs of the same colour. The original breed was extremely large, but at the same time exceedingly coarse; early in the century they were much improved, it is generally supposed by the help of the New Leicester blood. They are quite as large as the Lincolns, but coarser in their flesh and wool, and better adapted to poorer pastures.

The Cotswold has a very large frame with well-sprung ribs, flat back, and fleshy rump, which often extends beyond the

perpendicular line of tail; good legs of mutton; chest broad and prominent. The neck is rather long and arched upwards, with a large head, prominent eyes, and a slightly Roman profile. The crown of the head is well woolled; the rams have a lock hanging down between their eyes, which gives them a rakish and attractive appearance.

These sheep are not favourites with the butcher, as their meat is coarse and the fat is not laid on uniformly with the lean. They have heavy curly fleeces, but the wool is by no means of first quality.

The average dead weight of the mature sheep varies from twenty-six to thirty pounds per quarter. Rams of this breed have been known to come to enormous weights, over eighty pounds per quarter. The average weight of the fleece may be taken at ten to eleven pounds.

The Cotswolds are very much used for crossing with other breeds, to improve their size and give good constitutions. The one objection against them for this purpose is, that they too often throw lambs with large heads, consequently small ewes experience difficulty in lambing. Large numbers of these rams are exported yearly to America, Australia, New Zealand, and other parts of the world.

The **Romney Marsh**, or Kentish, breed, like most other long-woolled sheep, have been improved from the original type by a few dashes of Leicester blood; but of late years their breeders have simply relied on careful selection for their improvement, remembering the fact that "Like begets like." By breeding from the fittest, they now possess a symmetrical and valuable breed, which are able to withstand the exposure and extremes of temperature peculiar to their district, better than any other breed. The ewes in winter live where many breeds would starve, on exposed grass lands, where they are not only exposed to bitter blasts from the English Channel, but have to scrape away deep snow with their feet in order to get at the herbage beneath. In this they rival the Scotch Mountain breeds. They are a white-faced, large-framed, heavy-woolled breed, but inferior to the Lincoln both in weight of meat and wool. They are favourites with the butcher. Their wool is of good quality, and exceedingly saleable.

The tegs off turnips weigh from seventeen to twenty pounds per quarter, dead weight: two shear wethers, from twenty-five to thirty pounds per quarter.

Fleeces from the ewes and hoggs weigh on an average about seven to eight pounds; from two-shear wethers, about ten pounds.

Devon Longwools, chiefly found in the West of England, are a large white breed, established about sixty years ago, by crossing the old native Bampton breed with the new Leicester; and probably the Cotswold blood was also brought into service. They very much resemble the Leicesters, and in Cornwall are sometimes spoken of as the "Long-woolled Leicesters." They differ from the Leicesters in having longer and larger faces and ears, with a thick tuft of wool, or "cob," in the front of the head; their frame is larger and higher, but their ribs are not generally quite so well sprung, which makes them appear to have flatter and deeper sides. They carry a much larger fleece, of an open character. They are a grand-looking breed, well suited to the better classes of land of Devon, Somerset, and Cornwall. They are fast growers; hoggs from fourteen to fifteen months old off turnips, as a rule, scale from twenty-two to twenty-five pounds per quarter, dead weight.

It is usual in the west of England to clip the lambs, which cut as a rule about three pounds of wool each, whilst the mixed fleeces of hoggs and ewes average about nine to ten pounds.

The ewes, as a rule, lamb in the beginning of February, and are fairly prolific.

The **South Hams** are also a Devonshire breed, but are more like the Romney Marsh sheep than the Devon Longwools. The breed was established by crossing the old Bampton sheep with Cotswold and Lincoln rams.

They are a large-boned, stout-framed sheep, carrying a thick and heavy fleece, with a little coarse wool extending below the hocks on the sides of the hind legs, and a tuft of dark-coloured wool, or "top knot," on their forehead. The face is of a darkish white colour, of fair length; the skin should be very black on the muzzles; ears dark inside, with black spots outside; neck stout, and fair length; good back and strong hind quarters; the legs should be white. Some strains have a tendency to throw sheep with white muzzles and ears; these sheep are sometimes very large, but usually plain behind the shoulder, and altogether rather bad specimens of the breed. In a breeding flock these points must be carefully avoided. Some occasionally have brownish hair on their legs and faces; although these sheep are often very hardy, and make fine animals, they must be avoided in a breeding flock, as they are not characteristic of the breed. This brown hair indicates that the ancestors, at some time, have been crossed with Dartmoor blood.

Some breeders in trying to produce very large rams with heavy fleeces, often do so, but at the expense of the general form; these sheep are often deficient behind the shoulder,

and not the thick, well-proportioned specimens which are typical of good breeding.

The average weight of a good flock of fat ewes would be about twenty-five pounds per quarter; hoggs, about ten to twelve months old, eighteen to twenty pounds per quarter. Lambs are often sold, fat, at about twelve pounds per quarter. This breed has greatly extended its area of late years, especially in Cornwall. Formerly on the good land scarcely any sheep but the Leicesters were to be seen, but now a pure-bred Leicester is almost a novelty. On many of the good farms, the Leicesters would keep fat at all times of the year, but the butchers complained of the proportion of fat to lean meat, and when South Hams were to be had, Leicesters were often left unsold; the consequence was, South Ham blood became in great demand. Many pure-bred flocks were started, and the rams were almost universally used to cross with Leicester ewes; and farmers, who then owned Leicester flocks, have since gone on using South Ham rams; consequently, after a few generations, very little of the Leicester blood can be distinguished. The cross with the Leicester has proved a very excellent one. These sheep have good constitutions. The ewes are excellent nurses, and fairly prolific. It is usual in South Ham flocks to find about 50 per cent. of the ewes with twins.

The **South Downs** can boast of a longer pedigree than any of our British breeds—it is said that their descent can be traced farther back than the time of William the Conqueror,—and for this reason they are known in the shepherd world as the "aristocrats." They have done for the short wools very much what the Leicesters have for the long wools, as all the Down breeds have been improved by the addition of the South Down blood. The importance of this breed has been more on account of the good service they have done in refining and improving coarser breeds, than anything else.

The original South Downs, found on the chalk hills of Sussex, were much smaller than the breed we now possess, with grey or speckled faces and legs, instead of the more uniform brown that now prevails. It is questionable if the mutton was not even of a finer flavour than it is at present, and still it fetches the best prices obtainable in the London market.

About the end of last century, the South Downs were very much improved by John Ellman, a noted and careful breeder; and since then it is probable that Leicester or some other blood has been used to give them greater size.

Description of a South Down.—Face and legs, uniform colour, but varying on different classes of soil, being dark brown on

good soils, and usually lighter or fawn-colour on the thin chalk hills. The head is rather short and small, with wool on their forehead and between the ears, which are set rather widely apart; they should be perfectly free from horns. The eye is full, but the frontal bones (above the eye) should not be prominent; being small sheep, they would form obstructions in lambing. The neck should be straight on the top (not ewe-necked), fair length, and thin where it joins the head, getting wider at the shoulder.

FIG. 84.—South Down ram, "Royal Newcastle"; property of Mr. Edwin Ellis.

The breast is an important point with judges and graziers. It should be wide, deep, and projecting well forward between the fore legs. A sheep with a good chest is usually a good weigher, thriver, and possessor of a good constitution. The shoulders should be level with the back, and not wide at the withers; when sheep of this breed have wide shoulders they generally fail behind them, and measure badly round the girth; this gives them an awkward appearance. The back should be flat, and the ribs should project horizontally from the spine, but inclined backwards, and be well ribbed back to the hips, which are wide. The rump should be long and broad; the tail set on high, very little below the level of the backbone. The hind legs should be wide apart, and, if anything, turning outwards (not cow-hocked); the fore legs should be straight, not knock-kneed. The body, including belly, is well covered with short, fine, and close wool.

The ewes are prolific, and good nurses. The breed is hardy,

and fatten quickly when well fed. They are particularly well adapted for grazing on lofty downs.

The average dead weight might be taken at from fifteen to eighteen pounds per quarter, varying very much with the quality of land they are kept on.

Hill sheep shear about three and a half pounds per fleece, whilst five pounds may be taken as an average lowland fleece.

Shropshire Downs originated, in the first place, from the native breed which had horns. Mr. Samuel Meire is supposed to have been the founder of the race. He purchased some of Mr. Ellman's South Down rams, and crossed with the native ewes; this had its desired effect in removing the horns. The cross was well suited to the downs, but not adapted to the small fields of the lower lands; so, in order to get something more quiet and contented, the Leicester blood was added. This proved a great success, and since then the breed has been kept pure and true to type by selection alone.

These sheep somewhat resemble the South Downs, but are larger, head much more covered with wool, and legs of a darker colour. Face and legs black, head fairly wide, and very thickly covered with wool; good backs, with deep legs of mutton. They are well covered with a closely set fleece of fine wool, which handles somewhat like a sponge.

The wool of an ordinary flock might average six pounds per fleece.

Shearlings commonly weigh eighteen to twenty pounds per quarter; whilst it is not uncommon to see two-shear rams forty pounds per quarter, dead weight.

The ewes are exceedingly prolific, and make excellent nurses, and are well suited for bringing on fat lambs for the butcher. These fat lambs often make greater weights than those of the same age from long-woolled and larger breeds, yet, kept side by side after being weaned, the long-woolled breeds leave them far behind at ten or twelve months old, thus pointing to the fact that they are not so well adapted for early maturity. When kept on poor land, Shropshires will thrive where long-woolled breeds could only exist. They are very hardy, and able to endure a great deal of wet. Their mutton is of excellent flavour, having the fat and lean well mixed; like the South Downs, they are great favourites with butchers.

Hampshire Downs have come into great prominence of late years, being suited to all purposes, and make especially good weights at an early age; they are found chiefly in the South of England.

This breed was originated by crossing the old Wiltshire

horned, and Berkshire knot with the South Down. Although this cross was made at the beginning of the century, yet it was not until about 1846 that breeders assumed a uniform type amongst these sheep, which are now quite distinct from any other Down breeds. They have black faces and legs, a Roman profile, and a sourness of countenance which points to their origin; they are larger than the Shropshire, and less woolly about

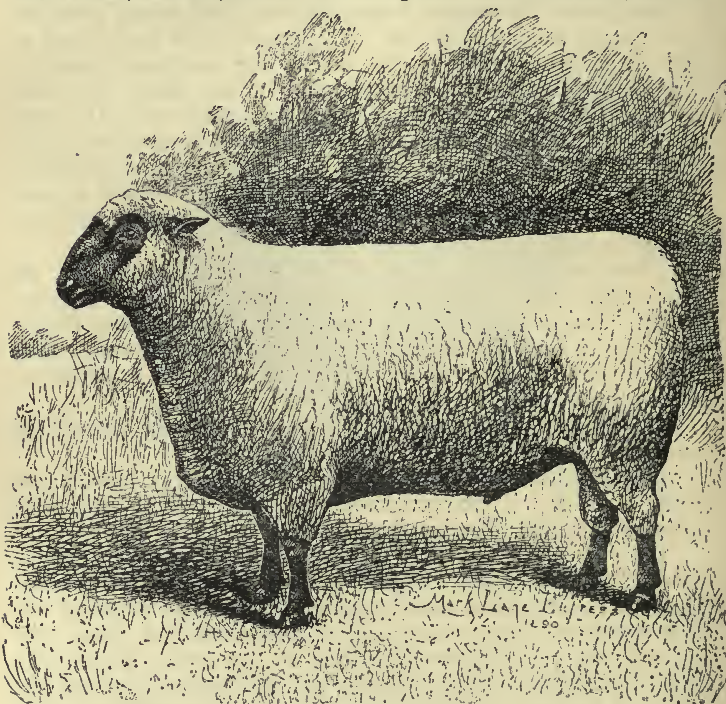


FIG. 85.—Hampshire Down.

the head, the ears are often inclined to droop; they are wide across the top of the shoulders, but often fail immediately behind; they have less wool than the Shropshires, and it is not so valuable per pound. As these sheep undergo such very varied treatment, some being very highly kept, their fleeces vary very much, but five to six pounds may be taken as an average.

The hoggs, fed on roots, make from eighteen to twenty-four pounds per quarter, and show shearlings get to very great weights.

The **Suffolk Downs** have of late years come into great repute

in their own and neighbouring counties. Their breeders started a flock-book in 1887, with the usual result of improvement, especially as regards uniformity of type.

They are in appearance very like the Hampshire Downs, with black faces and legs, but generally less wool on their heads; they are not quite so large nor so popular as the Hampshires.

FIG 86.—Suffolk Down ram, "Bismark 4th."

They originated from a cross between the old Norfolk breed and the South Downs. The old Norfolks had horns, and are described as being a very restless breed, and therefore not much inclined to lay on fat; their mutton, however, was of excellent character. The result of the cross with the South Down was very satisfactory, the progeny being black-faced and hornless, with the constitution of the old Norfolk, with a greater aptitude to fatten and come early to maturity. They are well adapted to grazing spacious downs, and also do well and make good returns for more generous feeding.

The **Oxford Downs** are a fine breed of sheep, carrying heavier fleeces than any other of the Down breeds. The points aimed at when this breed was founded were, to get a class of sheep that should combine the weight of a Long-wool with the quality of a Down. The breed was obtained by crossing Hampshire Down ewes with grey-faced Cotswold rams, and also a little South

Down blood was used. By constant selection of the most likely animals a most successful result was attained; from this selection, without any further admixture of other blood, we have an exceedingly uniform type throughout the whole breed. They possess good constitutions and large frames.

They may be described as follows:—Faces and legs dark colour, not grey or spotted; the poll should be well covered with

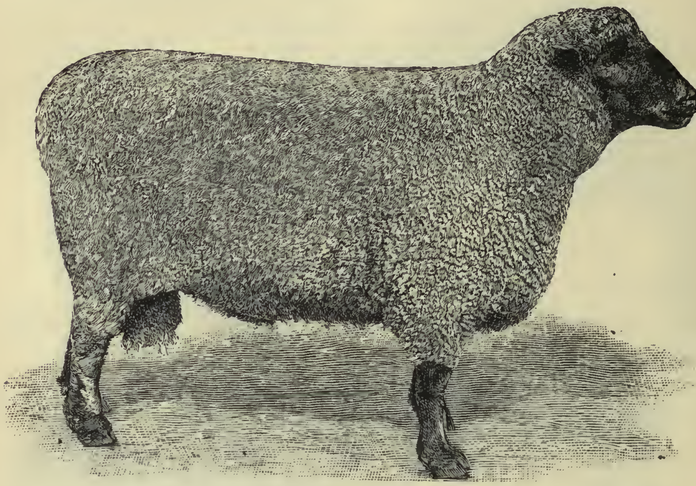


FIG. 87.—Oxford Down ram, "Progress" (719); bred by John Treadwell, Aylesbury.

wool and a topknot on the forehead; eyes should be bold and prominent; a heavy fleece of thickly set wool, and not too curly; a well-formed barrel on short dark legs, and good firm mutton of superior quality.

The hoggs are often sold fat at twelve months old, weighing from twenty to twenty-four pounds per quarter when well fed.

An average flock fleece might be taken at seven pounds, but shearling rams often clip double that weight.

These sheep are particularly adapted for close stocking, and feeding between hurdles. It is the prevailing breed in its own and neighbouring counties. Many of the rams are sold for crossing with other breeds.

The ewes are good mothers, and drop a large proportion of twins.

Upland and Mountain Breeds.

The **Cheviots** have long inhabited the mountain pastures of the South of Scotland, where they are to be seen in great numbers. They, like other breeds, have been much improved from the original type, which has been described as a small ill-framed animal with brownish-white head and legs, with a very hardy constitution. They were much improved by Mr. Robson, of Belford, who crossed them with, some say Lincolns, others, Leicester rams; probably the latter was the breed used. They have usually

Fig. 88.—Cheviot ram.

a very white appearance; but occasionally grey or dun faces are found in the purest flocks, and are looked upon as an indication of superior hardiness. The ewes are hornless, but the rams often have horns.

The head is erect, long, and clean, and should be perfectly free from wool, the eye very prominent, dark, and lively; the

ears are long, open, and well covered with hair. The head altogether has a very characteristic appearance, and if a sheep possesses any cheviot blood it is not hard to recognize. The legs are moderately long, clean, and fine. The body is fairly long and heavier behind than in the fore quarters. The rump is full, and tail neatly set, rarely cut, reaching to the hocks and well covered with wool; as these sheep are generally grazing on exposed ground, the tails are left long as a protection for the udder and belly from cold winds.

The neck and chest should be full; the wool on the neck stands in an erect position behind the head. The pelt is thin and well covered with wool, which is fine and free from hair.

Fleeces from an average flock would weigh from four to four and a half pounds. The fineness of the wool much depends on the nature of the pasture the sheep have been kept on; the finest wool comes from dry sweet pastures.

Ewes, when fat, weigh from fourteen to eighteen pounds per quarter, whilst three-year-old wethers finished on turnips reach from eighteen to twenty pounds per quarter.

The ewes are very prolific, and good nurses. These sheep are only excelled by the Blackfaced Mountain and Herdwick breeds for hardiness. They are largely used for crossing with Border Leicester, Lincoln, Oxford Down, and other rams. These crossbred lambs are very much liked by the Northern farmers, who buy great numbers of them to feed on their roots. They are larger than the ordinary Cheviot, and come earlier to maturity. The Border Leicesters are the rams that are most commonly used, the first cross being "half-breds." These ewe lambs are often kept and mated with a Cheviot ram, the produce being known as "three parts bred Cheviots." The mutton from these crossbreds is fine flavoured, but not quite equal to the pure Cheviots.

The **Scotch Blackfaces**, Heath, or Mountain Sheep.

These are found in great numbers on the exposed Highlands of Scotland, being hardier than any other breed. They are fond of getting at the mountain tops, where the herbage is of the coarsest character. If a sheep farmer from the south of England were to visit the West Highlands he would be puzzled to see what these tiny sheep found to live upon on these hill-tops, and would certainly be inclined to doubt that they could ever exist through the severe winters, when the hills are covered with snow for weeks together. Often their only chance of getting food is by scraping away the snow with their feet, until they approach the scanty herbage below. The young sheep, as a rule, are supplied with hay; but many of the older ones have to scrape and find their own living.

Both ewes and rams have horns. The horns of the ram are spirally twisted and large, getting larger with more spiral twists with age; the horns of the ewe are rather flat and arched, but not spirally twisted. The faces and legs are black or black and white (dappled). The face is long, clean, and glossy; the muzzle free from wool; a Roman profile is preferred. Eyes full and

FIG. 89.—Scotch Blackface ram, "Aaron;" bred by James Archibald, Overshiels.

bright. The neck usually low and a little long; back short; sides flat and deep. Hind quarters heavier than fore. Tail usually uncut, as it rarely comes below the hocks in the natural way. The wool is long, open, and wavy, almost reaching the ground; it should be free from black spots, and hard, wiry, white hair; the quality is coarse and generally used for the manufacture of carpets. The fleece usually weighs from three to four pounds.

In former years Blackfaces were regarded as slow growers and fatteners, and the wethers were rarely fattened till they were three years old; but of late years the quality of average Black-faced stocks has been so much improved, and early maturity so much developed in the hardy mountain breed, that they are now fully matured at eighteen months old, and vast numbers are sold fat by the time they are ten months old.

The ewes are good nurses when they can obtain a reasonable

supply of food; but in bad seasons, when food has been particularly bare, shepherds have sometimes to kill the lambs to save the mothers. Owing to the scarcity of food in the spring of the year, these sheep are not allowed to lamb until very late in the season.

The quality of the mutton from this breed is excellent.

These Blackfaces are sometimes crossed with Leicesters for the lower lands.

The **Herdwicks** are supposed to have originated from some sheep cast on shore from a ship that was wrecked on the Cumberland Coast, belonging to the Spanish Armada. They soon became very popular with the hill farmers. Consequently these sheep spread from one hill to another until they were to be found on the hills of Cumberland, Westmoreland, and Lancashire, and are still to be found there. Some Cumberland farmers, who have changed their quarters to North Wales, have taken some Herdwick sheep with them, with very satisfactory results. They find them hardier than the Welsh; when the two breeds are kept together on the same hill the Herdwicks will usually be found on the loftier positions. They are often crossed with Leicesters, and these cross-bred lambs are sold to the lowland farmers, who feed them for the butcher, as hoggs. The breed may be described thus: the faces and legs of the lambs are almost black, but get much lighter with age; by the time they are two years old they get a steel-grey colour, being lighter coloured towards the nose than forehead. Any brown tinge is supposed to indicate a less degree of hardiness, whilst a black tinge is not objected to. The head should be long and bold; ears white and sharp, and should stand well up—any tendency to droop shows a want of spirit, which is required by hill sheep. The eye bright, and forehead has a tuft on it. They should be wide between the fore legs, with a deep chest coming well forward, as the fore quarter is chiefly relied upon both for constitution and scales. The body is well ribbed up—but they are usually slack behind the shoulder. The hind legs are straight; the mutton reaches well down to the hocks. The knees and feet should be large, feet white, bone fine. The tail is thick, and should reach the hocks; bottom half of the tail often black. The ewes are not horned, but the rams usually are; the horns should curl once or twice, turning out and forward, clear of the side of the head. The mutton is fine in texture and flavour. The wool is of short staple, coarse, and open, but slightly better than that of the Scotch Blackface.

The average dead weight of a three- or four-year-old wether

varies from twelve to fifteen pounds per quarter when finished on the fells; on roots they may make twenty pounds, and show sheep sometimes attain twenty-five pounds per quarter.

The fleece averages from three and a half to four pounds.

The **Lonks** are found on the fells of Lancashire, Yorkshire, and some parts of Derbyshire. They are not altogether uniform in colour, some being much whiter than others. Whiteness is considered a sign of softness. The most approved colour for face and legs is black and white streaks. They have long bodies, but are usually wanting behind the shoulder and narrow on the loin.

The lambs shoot their horns with the new year, those of the wether never go beyond one curl. Breeders think a great deal of the horn, and consider it a measure of constitution. The horns are usually finer than those of the Blackface. The sheep are larger than the Blackfaces or Herdwicks, but not so hardy or suited to such great elevations. The ewes are good milkers.

For cunning the Lonks are said to be unrivalled. They are exceedingly fond of trespassing, and are great rangers. In taking a fence or wall they will equal a dog; nothing less than a strong, high wire fence seems to be sufficient to keep them within bounds. The wool is superior to the Blackface, and averages four and a half to five pounds per fleece, whilst an artificially fed wether may clip seven to eight pounds. Three-year-old wethers make eighteen pounds per quarter; show sheep may make nearly double that weight.

The **Welsh Mountain Sheep** are very small and hardy, but not very uniform in appearance. The mutton is excellent, and usually considered more delicate than from any other breed.

They are usually white-faced, but some are brown, some grey, and others speckled. The head is small, but carried high on a long neck. The rams have horns, but it is only rarely that they are seen on the ewes. The poll is generally clean, but the rams sometimes have a tuft on the forehead. The general frame is by no means a picture; they have a high rump and low shoulders, flat sides, very small behind the shoulder, and narrow chests. The ewes rarely produce twins, but they are good nurses. They are sometimes crossed with Down rams, on the low land, to produce fat lambs.

The average weight of the ewes is about seven to eight pounds per quarter; three-year-old wethers, nine to ten pounds per quarter, dead weight.

The wool is not of good quality, being very much coarser from some districts than others. The average weight of the fleece is from three to four pounds.

The **Exmoor Sheep** are to be found on the hills of North Devon and West Somerset. Some are also found in South Devon. Many attempts have been made to remove them from their native hills by the introduction of Cheviots and Blackfaces; but, in all cases, the Exmoors proved more adapted for their native hills: consequently, the northern strangers went to the butcher, and the natives again returned to their hills and pastures.

These sheep have very strong constitutions, and can endure great cold and privation during snow-storms. It is a common thing on the hills to have them buried in the drifts of snow for several days together, which they appear to stand wonderfully well.

They have white faces and legs, horns curving downwards and outwards, high necks, good loins, round ribs, a barrel-shaped carcase on short legs, woolled well up to the cheeks, and closely set fleece.

They vary much in weight, as many flocks are kept on fairly good land, while others have very meagre fare on the exposed hills. The average of the best flocks might be taken as sixteen to eighteen pounds per quarter, whilst there are many that would not be more than thirteen or fourteen pounds per quarter, dead weight.

The lambs are usually shorn, and clip from one and a half to two pounds.

The fleeces from an average flock (washed) will weigh about five pounds. The light-fleshed sheep produce least wool, but have a greater tendency to lay on fat.

The Dorset Horns, Dartmoors, and Ryelands could not correctly be classified under any of the three heads already described.

The **Dorset Horns** are a very old breed. They have been driven out of their own county, to a great extent, by the South Downs on the Chalk hill, and by the Shropshires on the Oolite. But still some Dorsetshire farmers stick to their native breed. In some parts of Somerset they exist in considerable numbers, and most of the principal breeders are Somersetshire men.

For the production of early fat lambs they are unrivalled. With proper management they may be made to breed at all times of the year, and they have often been known to drop two crops of lambs in one year. It is by no means uncommon to find Dorset lambs in the London and other large markets at Christmas and the early part of the year. In order to get fat lambs for this season, the ewes are tupped in April, generally by a South Down ram. They are used in small numbers, in many districts in the

south of England, for the purpose of producing these early fat lambs, which are sometimes house-fed. After the lambs are sold the ewes are usually fed and sold fat, commonly making twenty pounds per quarter.

They have white faces and legs; the nose and hoofs are also white; thin horns inclined to bend backwards, but curl well clear of the head. They have a tuft of wool on their forehead; the frame is neat, carrying a short, thick-woolled fleece, weighing four to six pounds, and lambs clip from two to three pounds. They drop a large proportion of twins, and are exceedingly good nurses.

The **Dartmoors** are a very hardy and useful breed of sheep, found, as their name would suggest, in South Devon and North Cornwall. They are remarkably well-adapted to the poorer classes of soils, and do well on the higher elevations of the districts in which they are bred. Their numbers are less than they were at one time, owing to the increasing popularity of the South Hams, which breed has in most cases taken their place on the better classes of soils. But on farms near the Moors, the Dartmoors are still, and are likely to remain, the favourite breed.

These sheep are thickly made, and carry very good fleeces; although the wool is usually a little coarse in character. Their faces and legs are uniform in colour, being as a rule either white or tawny, and sometimes speckled.

Ryeland Breed is a native of Herefordshire and South Wales. They are a very ancient breed, but the extent they now occupy is exceedingly limited. The flocks that now exist are scattered amongst the following counties—Herefordshire, Monmouthshire, Gloucestershire, Shropshire, and Warwickshire. They are well-formed sheep, with white faces and legs; a tuft of wool on their forehead; short legs; good loins; with exceptionally fine, close wool, covering the whole of the body. The fleeces weigh six to seven pounds.

The average dead-weight is about eighteen to twenty pounds per quarter, some making much greater weights.

The mutton is particularly good.

Management of Sheep.

In order to describe the management of sheep in a clear and practical manner, we will suppose that we are the happy possessors of a good general flock, on a mixed arable and pasture farm, of not too clayey a nature, suitable for carrying sheep the whole year round.

By describing what would be likely to take place with such a

flock during the year, we shall have full opportunity of touching on every point of management. We will suppose the year to commence at the beginning of August, it will then finish at the end of the following July.

The whole flock in August will be made up of three different lots, viz. (1) the old ewes that have been weaned from their lambs; (2) the shearling ewes, which have been kept to select from, to fill the place of the "drawn ewes" from the flocks; (3) the lambs that have been dropped that year. We are supposing, in this case, that the wethers are all sold, either as "hoggs" in the spring, or as "shearlings" during the summer.

For the benefit of the student it would, perhaps, be well to refer to the different names given to sheep of different ages, etc.

The young sheep, from time of weaning until shorn at one year, or usually a little over one year old, receive the names of "tegs," "hoggs," and "hoggets." In some districts the "hoggs" simply refer to the males, and "hoggets" the females; in others, both these terms are used collectively.

The males, when left entire, are "tup tegs," "ram lambs," or "hogg rams," until one year old, when they become one-, two-, three-, or four-shear tups, or rams, according to their age.

The castrated males are "wether hoggs," "wedder hoggs," "wether tegs," and "he tegs," and may become one-, two-, or three-shear wethers.

The females are "gimmer lambs" until weaned, they then become "gimmer hoggs," "ewe hoggs," or "ewe tegs;" and, in some districts, the term "hoggets" refers to these gimmer hoggs. After the first shearing they are called "shearling ewes," "gimmers," "theaves," or "two-teeth" ewes; whilst in the flock, two-, three-, or four-year-old ewes; and, when drafted, "draft" or "culled" ewes; if, after being put with the ram, they prove not to be in lamb, a "barren" ewe.

Management of the Ewe Flock.

Drafting.—In August or beginning of September the old ewe flock should undergo very careful inspection. Those that appear in any way unfit to be retained another year in the flock should be drawn out, "culled," or drafted.

The common reasons for drafting or culling ewes are the presence of ulcerated udders, large teats, or malformations of any kind; under size; loss of wool on belly, back, or neck; any that have been much subject to the attack of fly; any with bad teeth, as they will have difficulty in feeding, and will therefore be unable to keep in good condition or provide for their lambs.

If they have any signs of constitutional weakness, they should be culled. Swelling under the jaw is a symptom of liver-fluke, and any ewe in such a state should be fed as soon as possible, otherwise she may pine away. Aged ewes should be culled; they are usually indicated by bad teeth.

It is usually a mistake to keep a ewe in the flock too long. A ewe that is retained with bad teeth will probably be very thin by the time the lamb is weaned; the teeth will have got much worse by that time, and the ewe's constitution will be much weakened: consequently, it will be difficult to get her fat. She will therefore make much less money than she would have done if she had been fattened the year before, whilst a younger ewe would have been just as valuable in the flock.

The usual ages for drafting ewes are three or four years old, after they have had two or three crops of lambs, as the case may be; entering the flock as shearlings, and getting their first lamb at two years old. If any four-year-old ewe is particularly good, with a sound set of teeth, she might be kept another year. In a breeding flock, where the object is to breed good rams, ewes of particular merit are sometimes kept until much older.

Some breeders tup their gimmer hoggs, in which case they lamb at one year old. Ewes lambing at this age are supposed to make better nurses at two years old, than when allowed to run another year. Early breeding tends to develop milking qualities, but it retards the growth and interferes with the development of the frame; for this latter reason many breeders condemn the practice. When this system of early breeding is practised, the ewes should be very liberally treated, both before and after lambing.

Flock-masters are rather divided in opinion as to whether drafting at three or four years old is the better plan. We are inclined to consider the four-year-old system the better.

In drafting at three years old, the ewes only get two crops of lambs, consequently half the flock has to be drafted every year; whilst in drafting at four years old only one-third are drafted: consequently fewer gimmers have to be kept to supply the place of the draft ewes. To balance this, it would be only fair to say that the draft ewes at three years old would make more money than those drafted at four. There still remains a point in favour of the four-year draft system; that is, the four-year-old ewes produce more doubles and make better nurses than the two-year-olds, and usually cause less trouble in the lambing fold. As less gimmers, in this case, are required to supply the place of the drafts, a choicer lot may be selected.

We will suppose that we are in the habit of keeping a flock of

two hundred ewes, culling at four years old, and making the number good by bringing in shearling ewes (two-teeth) every year. Our flock of old ewes, which had been originally two hundred, would, by the month of August, probably be reduced to about 194, owing to deaths in the flock, or, perhaps, some having proved barren. Out of these 194 there would probably be seventy condemned and drafted. Most of these would be four years old, and should be branded with a distinct mark over the shoulder, in order to distinguish that they were culled ewes, in the case of their mixing with the flock again. After these seventy had been drawn, the flock would be reduced to 124. So it would then be necessary to select seventy-six of the best shearling ewes, and enter them in the flock, so as to make the required number —two hundred.

The **Culled or Draft Ewes**, together with any shearlings not selected for the flock, should undergo another selection. Any that were fit for breeding should be sold for that purpose. These would probably be purchased by a farmer keeping a flying stock (described later on). Those not fit for this purpose would have to be fattened for the butcher as quickly as possible, before food got too scarce. It is a good plan to have rape ready to put them on immediately they are drawn, as sheep feed faster on rape than on any other keep.

How to know the Age of a Sheep.—Any young farmer or agricultural student should be able to recognize the age of a sheep by examining its teeth. Perhaps the best way of obtaining this knowledge is to visit the shearing-houses; he will then have full opportunity of seeing sheep of all ages. Those that are being clipped for the first time will be from fourteen to sixteen months old, and will then be getting two broad teeth on their lower jaw, with three smaller ones, or the remains of three smaller ones, on each side—these being the temporary, or milk-teeth. When kept much on roots these milk-teeth often get broken. About twenty to twenty-two months old—about Christmas—they will have four broad teeth. At two years and three months old—about second shearing—they should have six broad teeth. At three years old they get eight broad teeth, and are then "full-mouthed."

Different breeds of sheep, and sheep under different management, will often vary a little as regards their teeth. In some cases they are much more forward than others; but in all cases (except mountain breeds) the indications of age given should answer for August and September, the usual time for drafting ewes and purchasing rams.

Flushing the Ewes.—Before the rams are turned with the

ewes, they should be put on good keep in order to bring them into a thriving condition during the tupping season. When ewes are thriving, they take the ram much better than if they are in low condition; they also produce a greater amount of twins. They are often flushed on clover aftermath, and sometimes on mustard or rape. It is a bad plan to overflush ewes, as they usually suffer more from loss of flesh during winter. The best plan is to get them fleshy, and then keep them thriving whilst with the ram.

The Selection of a Ram.—In selecting a ram the following points are to be desired. It should be a young animal and a typical specimen of its breed, possessing a good constitution, a strong, thick, muscular neck; a level, broad back; a well-formed rump and thick dock; a deep and broad chest; well-sprung ribs; good legs of mutton; strong fleece, varying in abundance with the different breeds; small, neat, masculine head, with a good countenance; strong feet, and active movements. Such would be the kind of sheep likely to do good service in any flock.

It is not desirable to get a ram with too large a head, as this point may be transmitted to the offspring, and thus cause a great deal of difficulty in yeaning.

The feet should always be well examined, to see that there are no traces of foot-rot. Any lameness should be looked at with suspicion.

Spirit and activity are essential points, as slow and sluggish rams are often bad lamb-getters.

The usual time for putting the rams with the ewes is in September and October on lowland farms; but as late as November and December on hill farms.

In the south of England, where plenty of keep can be provided in spring, the ewes generally get the rams at the end of August or the beginning of September, so as to lamb early in February. But in the north, March and April are more common months for lambing; whilst on the hills they often lamb as late as May and even June, in order that the ewes may be able to find some keep to provide for their lambs.

Dorset Horns are often tupped in May and June, for the purpose of producing winter lambs.

The period of gestation in a ewe varies from twenty to twenty-two weeks.

The number of ewes allotted to each ram is usually between forty and sixty. The smaller the breed, and younger the ram, the more ewes it will cover.

For our flock in question—two hundred—four rams would be required. It is a common practice to use a good ram in the

same flock two seasons. The first season it would be a shearling, and the second a two-shear tup. In some exceptional cases, where a ram has produced very good stock, and still possesses plenty of life and vigour, it is kept another year. In such a case, great care should be taken that he is only mated with the old ewes, as some of the shearlings that would enter the flock during his third service would be his own offspring.

When four rams are used, two should be shearlings and two "two-shear tups;" then, by purchasing two shearlings every year, the number would be kept up.

Selection of Ewes for Different Rams.—Some flock-masters place the rams indiscriminately amongst the whole flock of ewes. This, of course, saves trouble; but the practice is not to be recommended. As the ewe lambs will eventually enter the flock, great care should be taken in selecting the most suitable ewes to be mated with each separate ram. For instance, ewes with heavy fleeces, and not so much inclined to lay on flesh, should, if possible, be mated with a ram which possesses the quality of laying on flesh in a high degree. Ewes weak in their wool should be mated with a ram carrying a specially good fleece.

Shearling rams, when not over fed, are usually more active than two-year-olds, and should generally have a few more ewes on this account.

In some cases ram lambs are used; but these should only be allowed to serve a limited number of ewes, otherwise it may materially interfere with their growth.

Smearing the Ram.—It is usual to smear the breast of the ram, just between and behind the two fore legs, with red ochre and grease. This should be applied before the ram is turned with the ewes, and renewed about every two days. By this means it can be seen by the mark left on the rump, how the ram is working and how the ewes are taking him. After about three weeks, when several are marked, the colour should be changed to blue or black—lamp-black and grease. An idea may then be formed as to which will lamb early and which late.

In some small flocks the ewes are all numbered. In this case a record can be kept of the dates that each ewe takes the ram. In some cases they do not hold the first time, so the last date must be taken. The black marking shows very distinctly over the red.

Use of a "Teaser."—In a case where an especially good ram is required to serve a large number of ewes, it is advisable to keep him in a small paddock with a few ewes for company. The rest of the flock should be supplied with any ordinary or second-rate ram, with a double piece of sacking hung in front of his genital

organs. This prevents him from serving the ewe, but enables the shepherd to see when each ewe comes into season, when she is taken to the paddock to be served by the selected ram. There is naturally a great deal of labour connected with this plan; but the ram will effectually serve a much greater number of ewes than when allowed to run with the whole flock, as the energy required for the preliminary performances is expended by the teaser.

The ewes should be kept in a good thriving condition whilst with the ram, and for a short time after, and should never be allowed to drop much during the winter.

After the ram is taken from the ewes they are usually run on the leas and pastures,—unless on a purely arable farm, when they are folded on roots after feeding sheep. They should be kept in good healthy condition during winter. Good managers avoid the two extremes of having them thin and stinted, and of getting them in too high condition. Good sound dry pastures to run on, with the addition of a few pulped roots mixed with chaff and a little crushed oats, if required when the pastures are bare, is the best keep for in-lamb ewes.

It is often the case, when the pastures get eaten down, that the ewes are allowed to fall very much in condition, just for the want of a little extra food. In such cases the ewes usually take to ranging, consequently the young fœtus gets turned or twisted in some way. This causes great difficulty in lambing, and often results in dead lambs, or, in bad cases, even death of the ewe during parturition.

After ewes have fallen in condition, they are often supplied with whole roots, spread over the field, which they rush ravenously after. This is very likely to twist the fœtus. If these roots are given in large quantities near the lambing season, they often cause the young fœtus to become dropsical, when it is impossible to take it away alive. When ewes are on pasture during winter, it is far better to reserve the greater part of the roots until after they have lambed, and supply them with chaff, a few pulped roots, etc., as before mentioned.

Barren Ewes.—It is not uncommon to find a few barren ewes amongst the flock. Some rams leave more than others. Just before the lambing season commences, any that may be suspected as being barren should be picked out and tested.

There are several different ways of detecting barren ewes. The first thing that would naturally strike the eye of the shepherd, or an experienced flock-master, would be their light walk, flatness of sides, and lightness in belly, as compared with the other ewes. Any dirt about the tail is often a sign of barrenness. But none

of these indications are to be relied upon in the case of the ewe being a late lamber.

If these suspected ewes be drawn out and put on a high, banky field, with young ewes, the barren ones will usually be exceedingly active, and will commence butting and skipping. A ewe in lamb rarely skips, however much she may be enticed to join in the fun by a barren one. This skipping is a very sure test. A fine day should be selected, and there are certain fields on every farm, in which they are more likely to reveal the secret than others; the shepherd, as a rule, knows them well. It often happens that they skip when with their own flock, but are more likely to do so when with younger sheep. Another test is to turn the ewe and examine the udder. If barren, she will show no signs of secreting milk, will usually have waxy matter developed in the wrinkled skin around the udder, and the wool will generally be stronger in growth than that on an in-lamb ewe.

If these ewes are in good condition, or can be got in good condition quickly, it is often advisable to sell them in the fleece. As a rule, mutton fetches a good price at this time of the year. If, however, the demand is not good enough to keep the prices up, it may be better to keep them to clip, and sell them fat shortly afterwards.

Management of Lambing Ewes.—A week or so before lambing, some of the most forward ewes should be picked out and given a little extra food, in order to get a good flow of milk. When they commence lambing, they should be brought to a sheltered lambing paddock, fitted with lambing pens, which may be erected in a variety of ways.

The **Lambing-fold** is often made of hurdles filled between the bars with young twigs or stiff straw. A row of pens should be arranged on one side facing the south; the back of the pens should be made of high wattled hurdles. The roof consists of hurdles placed at an angle, higher in front than behind, and thatched with straw. Hurdles are set at right angles to the back, so as to form the necessary partitions; then another row in front, acting as gates, make the pens complete.

In front of these pens there is a large yard enclosed by ordinary hurdles. This yard is again divided into three; the largest portion being occupied by the lambing ewes, and the other two by the ewes and lambs a few days old, which are still too young to be driven from the fold. The smaller of these divisions is occupied by the newly lambed ewes and their offsprings, as they are brought from the pens; whilst the other contains the ewes and older lambs, which are about to be taken to the fields.

The sheds or pens should be fairly wide, but not too high.

As sheep are naturally accustomed to exposed positions, rather than close buildings, they do not do well if they are packed too closely in a yard.

In selecting a site for a folding yard care should be taken to pitch on a good, dry, well-drained bottom, otherwise the ewes will be almost unable to move after a few days' folding. Burnt clay makes an excellent bottom for such a yard; this, covered with short straw, or stubble, is much preferable to the use of long straw, which gets entangled about the ewes' legs. As the dung accumulates, it should be cleaned out.

There should always be a waggon of good hay in the middle of the fold, also some straw and roots near at hand, and a necessary supply of racks and feeding-troughs.

Sometimes, in the place of hurdles, a long wooden shed is erected, and partitioned off into a number of little hutches, the roof being covered with felt. The yards may be made much like those described.

On some large sheep-farms permanent sheepfolds are built of masonry; but, as a rule, the movable ones are more convenient. In addition to the large fold, small ones are erected at intervals on the sheep-run, so that any ewes that may lamb on the pastures through the day can be taken to the nearest one.

On small farms, where only a few ewes are kept, they are usually sheltered in an empty Dutch barn, or any available well-ventilated house. They should be brought to these folds by night, and turned to the fields again early next morning, and should only be kept in a yard all day in the case of very severe weather.

The shepherd has a small wooden hut on wheels, in which he has his bed and a necessary supply of medicines. This hut is kept close to the fold.

In Devon and Cornwall sufficient shelter is usually afforded by the banks, which are often five feet high, with scrub growing on the top, such as thorns, black withies, etc. These high fences break the wind, and make a small paddock very sheltered. If the field is fairly square and dry, with the longest hedge towards the rainy quarter, and no water allowed to lodge in the ditches, the ewes will much prefer this kind of fold to any other. They usually get much better flushed in milk when allowed to remain outside, than they do when brought under cover.

When ewes are about to lamb in the field, they will select for themselves a dry, clean spot by the sheltered hedge, generally at a little distance from the rest of the flock. They usually walk backwards and forwards, pawing any loose soil, such as a mole-hill, and giving vent to an occasional bleat; these are the usual

indications of approaching parturition. After a time they may be seen to go on their side, with their head towards the hill, and make great efforts to expel the lamb. They may fail to do so, and rise again, but soon return once more to their side, and, with a great effort, usually achieve their object. The lamb lies on the ground, whilst the mother rises and licks the mucous film from its body. It then shakes its head, flaps its ears, and soon tries to get on its legs, which, after a few stumbles, it succeeds in doing. Its gait is certainly a little awkward to start with, but, if it is a good healthy lamb, it will soon establish itself by the ewe's side, put its nose under her flank, and partake of the food that nature has provided.

If the ewe is going to bring forth twins, she will lie down again, and, as a rule, bring forward the second with greater ease than the first. They sometimes become fonder of one lamb than the other, usually preferring the stronger (referred to later).

Difficult Parturition.—It often happens, when ewes are carrying a large single lamb, that they are unable to bring it away. In such cases they should be rendered assistance, but not before there is any occasion. Ewes should always be allowed to try and expel the lamb naturally, and, if left to themselves, will often do so. If, however, the case appears to be too much for them, and a water-bladder, foot, or nose makes its appearance, they should at once be assisted. If the lamb is coming in a natural position, it will have its fore feet and nose coming first. The ewe should be held down on her side, and one of the lamb's fore legs pulled forward at a time, then, by pulling the two towards the udder and at the same time helping the lamb's head forward with a finger from the left hand, the lamb can generally be extracted. Directly the head is clear, the lamb should be pulled quickly away, for, if the walls of the vagina are allowed to press on the thorax of the lamb, it will soon die from suffocation. When the lamb is taken, it should be laid by the ewe's nose, its mouth should be opened and side patted with the back of the hand. After it shakes its ears it may be left to its mother, and watched to see that the mother licks and takes kindly to it.

It sometimes happens that the nipples of the teats get stopped up with peculiar secretions; in this case the lamb can abstract no milk. They may easily be cleared if pressed between the finger and thumb. The milk will be slightly thick at first, but will soon run freely.

During the lambing season the shepherd is troubled with cases of abnormal presentations, which cannot be dealt with here.

Monstrosities.—We have occasionally seen great difficulty caused in lambing by monstrosities; such as a lamb with two

heads, two bodies and one head, or—perhaps the more usual thing—a lamb with more than four legs.

Dead Lambs.—If there is one thing a shepherd dislikes more than another, it is having to take a dead lamb. He knows before he starts that there is a great chance of losing his patient; he also knows that there is more chance of losing her if she is left alone. In these cases the ewes rarely come in labour in the natural way. The pelvic bones are not usually very open, and in many cases the ewes try very little to expel the lamb. The symptoms are that the ewe stands alone, with her ears drooping, eyes dull, and, instead of chewing her cud, she will often grind her teeth.

It is often necessary to take the lamb away in pieces, as the neck of the womb is contracted. It is usually a very difficult case, and, as the ewe is in a delicate condition, she does not stand the operation well; the chances are that inflammation sets in afterwards, and in many cases the ewe dies. They sometimes live for a few days, and then die; this is often due more to the fact of their not cleansing properly, than the effects of the operation of taking the lamb.

If the lamb has been dead any time it becomes putrid, and gives off an exceedingly disagreeable smell.

When assistance has to be given to a ewe it should be remembered that it is a bad practice to be continually putting in and withdrawing the hand. The same thing applies to too many people having a hand in the operation, as in either case a warm hand is withdrawn and a cold one replaced; this naturally causes irritation, and inflammation follows.

It is a good thing to wash the hands in warm soapy water before commencing the operation; they should, as well as the uterus, receive a disinfectant dressing afterwards.

A very common disinfectant is made with eight parts of gallipoli oil, and one part of carbolic acid; usually called carbolized oil.

For further information, the student should refer to the chapter on "Veterinary Science" (pp. 261–264).

When ewes are in a delicate state, and have to be penned after lambing, they should get some gruel. They often refuse ordinary food, such as roots or hay; if a little ivy can be procured they will often eat it greedily, also young shoots of thorns may tempt them; as they get stronger they will take to a little cabbage.

The Shepherd's Difficulties with the Mothers and Lambs.—The shepherd has difficulty in getting some ewes to recognize their offspring. Some young ewes, lambing for the first time,

appear rather frightened at the operation they have undergone, and get up and take no notice of the lamb. In such a case as this the pair should be penned, and the lamb put to suck its mother; after a short time, with a little trouble, she usually becomes very fond of it.

Some ewes, when lambing twins, become very fond of one and refuse to recognize the other. In a case of this kind the ewe should be kept alone, and both lambs taken away for a short time. The refused lamb should be well rubbed against, and under the tail of the favourite lamb, and then taken back to the mother alone. She will usually be only too glad to take it. As soon as she shows signs of being really fond of it, the second one should be taken back. We have often seen this plan result in the mother showing a preference for the lamb that was at first refused. If the ewe still refuses to take more than one of them, and she has milk enough to maintain the two, the shepherd must be still more persistent until he gains his point. Should the mother be a poor nurse and there happens to be another ewe which has lately lost her lamb, this second ewe should be given the refused lamb. There is often a little difficulty in getting her to take it; sometimes, by taking the skin off her own dead lamb, and putting it on the body of the lamb to be put on her, she may be deceived, and will often take kindly to it. If, on the other hand, she has rather an antipathy for the lamb, indicated by walking away from it, or butting it when close, she should be fettered and kept in a close place with the lamb. The fetter consists of a short rope which connects one hind leg with one front one. This prevents her from getting far away from the lamb, as it impedes her movements. She should be continually watched, and the lamb put to suck. She will soon stop for the lamb at hearing the shepherd's voice, and as soon as it can get an occasional suck for itself the fetter should be removed. When ewes have to be punished in this way, the flow of milk decreases; they should be kept outside as much as possible, as they give even less milk when confined in the pen.

Feeding with the Lamb Tin.—When ewes give only a little milk to commence with, their lambs require a little cows' milk, which should be given a little at a time, but often. It is a bad sign to hear young lambs crying; it is a sign of weakness, usually caused from their not getting as much milk as they require.

In some cases the mothers die and leave their lambs; these have to be hand fed, and are known as "pet lambs." They should be kept in a clean warm place, and fed with whole milk warm from the cow, out of a lamb-feeder. After a time skim milk may be mixed, and they will soon learn to take it

from a basin, which will be far less trouble. These lambs should be put out by day as soon as they get strong enough; they soon learn to pick grass, young seeds will agree with them best. They should be taught to eat a little cake and corn-meal as soon as desirable.

Weak Lambs.—The shepherd sometimes finds a lamb which has been exposed to wet and cold, almost lifeless, and may be inclined to pass it for dead; often, if such lambs are taken and placed in a basket in front of a good fire, they will rapidly recover. They should be given a little milk with some gin in it, and, as soon as they get strong enough, they may be returned to their mothers.

Management of Ewes and Lambs.—We will suppose that they are strong enough to be removed from the fold to more distant grazing, which would have been kept up particularly for them; the ewes with twins would be placed on the best grazing.

They should be supplied with some roots and hay, and, if the lambs are required to be forced, they may also get a little crushed corn and cake once a day.

When possible, the ewes and twins should be put on seeds.

In exceptional cases ewes have three or four lambs; these should be kept with the doubles, and receive a little milk from the feeder: occasionally some of these lambs are put on other ewes.

At the early part of their life these twins sometimes cause the shepherd a great deal of trouble and annoyance, as some of the lambs stray from their mothers and get mixed with others; they are then often difficult to sort. If the mother is not too flush in milk she will often show very little inclination to recognize the strayed lamb. When they are again sorted they should be seen to suck the mother, and, in the case of her not having sufficient milk, should be supplied with a little from the feeder. With good keep her milk will gradually increase, and in a short time the lambs will do without any from the feeder.

In a week or two the lambs will begin to nibble at a little grass and crushed corn or meal; as soon as they do so, they should have some in lamb-troughs, placed out of the way of the ewes, on the other side of lamb-hurdles. These hurdles are open enough for the lambs to pass through, but close enough to prevent the passage of the ewe.

Even when ewes and lambs are on seeds, some farmers prefer to give them a break at a time, rather than let them run over the whole field at once. This plan gives a little more labour, but certainly has its advantages. 1. The lambs can always run forward and pick fresh grass before the ewes. 2. Instead of keeping the flock for, say nine days, on one field, by having three

breaks it is just like having three changes; sheep always do much better when they are continually changed, than kept for a long time on one field. Lambs often scour if kept on one layer too long; the young shooting grass purges them.

In stocking seeds in the spring, care should be taken never to let them be eaten too bare. There should always be a supply of hay and roots in the field so long as the sheep will eat them, as well as a few lumps of rock salt.

The sheep on seeds intended for mowing, should not be left on too long, or it will seriously interfere with the hay crop. Where the climate will permit, there should be a supply of catch crops coming in succession, such as rye, vetches, and trifolium. They may be folded on this, or have a supply brought to them on pasture. These catch crops may be fed off in the summer in time enough to enable the field to be sown with late turnips. By this means a full crop of hay may be got from the seeds, and a greater number of acres will be available for cutting.

Castration.—The male lambs are castrated at different ages; from fourteen to twenty-one days old is usually considered the best time for the operation. They are sometimes done at a few days, and often at six weeks old. It is a bad practice to let them get too old, as they suffer so much more than when they are operated on at two or three weeks of age.

The weather should be taken into consideration; the day to choose should be a seasonable one, neither too cold nor too warm, but fairly dry. The operation should take place in the morning; they may then be examined several times through the day, so that if any bleed too much they may be bathed with cold water.

The operation is performed as follows. A man holds the lamb to his shoulder, with its legs tightly clasped in his hands. The shepherd opens the scrotum with a knife; the testicles are then drawn out; the cords may be pulled gently until they snap, they may be bitten through by the teeth, or may be cut with a knife. Some people use the searing iron, but it is not generally used for this operation. In some cases no dressing whatever is applied, but we recommend the use of a little hog's lard.

People who make it a practice to sell fat lambs often allow them to run entire, but even for this purpose wether lambs are to be preferred. They recover from the operation in a few days, get fatter on the backs than tup lambs, and are more sought after by dealers.

Docking.—With the tup lambs this operation is performed at the same time as castration. It is desirable to get the tails docked early in the season before the flies become plentiful; if the operation is not performed early it should be left until autumn. When

it is done in warm weather, the blood attracts the flies, and they deposit their ova in the dock; these soon develop into maggots, and cause the lambs a deal of irritation and pain, besides giving the shepherd a vast amount of work in clearing the lambs of the pests.

The usual length for cutting the tails of the larger English breeds, is at the third or fourth notch (vertebra) from the top; whilst it is common with mountain breeds to let it be level with the hocks, and, in some cases, they are not cut at all, the tails being left to serve as a protection for the udder and belly against the severe cold winds on the hills. Sheep with long tails are more likely to get dirty and attract the flies than those with short ones.

The operation may be thus performed: a lad holds the lamb by the wool under the neck, whilst the shepherd, with a strong knife in his right hand and the tail in the left, puts the wool back from the place it has to be cut through with the back of the knife; then with a sharp cut the tail is left in his hand, and the lamb passed through the gate or door, as the case may be. By the time the first is finished, a second lad has another lamb ready for a similar operation. They bleed a little after the operation, but not much.

A lamb that has been docked appears to have a much better rump than a similar one with a long tail; it gives them altogether a plumper appearance. For a few days after this operation the lambs should not be driven or collected with dogs, as fast driving often causes the tails to bleed.

Ear-marking.—The ear-mark serves as a distinction between different flocks in the same neighbourhood, each farmer having his own mark. It is usually done by what is known as taking a "halfpenny" out. The ear is doubled, and a sharp stroke with the shears does it; it may be taken out of the front or back side

FIG. 90.—*a*, hole; *b*, halfpenny; *c*, the ear doubled for cutting out the halfpenny.

of the ear. Another way of marking is to simply punch a hole through; some mark on the left and some on the right ear. By these means, farmers adjoining each other know their sheep if they happen to get mixed, as each man has his particular mark.

Lambs are ear-marked at all ages, it is sometimes done at a month old, and often at the same time as they are docked; in

any case, it should be not later than weaning time, otherwise they might stray and get another man's mark put on them.

During the summer, the ewes and lambs are usually run on the leas; in some cases a portion of the seeds are reserved for them, instead of being cut for hay. They should never be kept in one field too long at a time, as the pasture gets stale; it is often better to change them from a good field to a poorer one, than to keep them too long in the same field. When it is necessary to change their food, it should never be done too suddenly, as it often causes derangements of the bowels.

The Time of Weaning varies very much with the time of lambing. Some flocks are weaned at the end of May, and others not until the end of July. Perhaps the most general day for weaning in England is the 24th of June, whilst in Scotland it would be about three weeks later. We have noticed that lambs dropped at the end of February and the beginning of March, weaned about the 10th of June, have frequently done better through the winter than similar lambs weaned a fortnight later; we therefore do not recommend keeping them with their mothers too long. It must also be remembered that the sooner lambs are weaned the better chance the ewes have of getting in condition to take the ram.

One way of weaning is to take the ewes and lambs in a yard overnight, and separate them in the morning. If the lambs have not before been ear-marked, the operation should at this time be performed. The lambs should be taken to a good fresh field of grass, selected on purpose for them, and the ewes to a bare pasture, some distance from the lambs. Both the lambs and the ewes will be hungry, more especially the ewes, and on their bare pasture it will take them some time to fill themselves, and little time to think of their lambs. Both fields should be securely fenced before weaning, to prevent any chance of the ewes and lambs mixing again.

Another way of weaning: Instead of taking both the ewes and lambs to spend the night in the yard, some people prefer to let the lambs remain in the field that they have been keeping in, and take the ewes to the yard alone. When the lambs get settled down, after a day or so they are taken to better keep. It is usual to milk the ewes about twice after weaning. In many parts of England it is often done by the labourers' wives, who get the milk for their trouble; they mix it with cow's milk and make it into cheese.

The ewes, after weaning, are run on the leas and poorer classes of pastures after cattle, until flushing time again arrives.

On arable farms they pick up the leavings of other sheep, running behind the folds. When the lambs are placed in front of them, they have a double row of hurdles between, to prevent the lambs mixing again with their mothers.

The ewes are shorn sometimes before, and sometimes after, weaning (referred to later).

The lambs should be put on good keep, and, if on grass, should be continually changed from field to field. In some districts the weaned lambs are changed every day or two.

Both young sheep and young cattle do better on new pastures than on old ones. They usually do well on the aftermath (chiefly clover) that comes up after lea hay (first year's hay) has been cut. When first placed on this keep, they should only be put on a few hours at a time, until they get accustomed to it. If put on too suddenly in wet weather, they are apt to suffer from diarrhœa, colic, hoven or blown, and other ailments.

During the summer months, usually from May until the end of September, the shepherd is continually annoyed by the "blue bottle," and two or three other kinds of blowflies. Some districts are more subject to these pests than others; the lowland shepherds usually suffer more from them than those on the hill.

These flies are attracted by dirt, and deposit their ova on the wool of the sheep or lambs. In a very short time minute maggots are developed. These wriggle about and find their way to the skin. If the animal happens to have a wound, the ova are often deposited on it. As soon as the maggot develops, it gnaws into the skin and feeds on the sheep. Many hundreds may be seen at a time on a single sheep. They usually strike on the rump, tail, back, or thighs. As soon as they break the skin a greasy fluid oozes out, and makes a dark wet place on the wool; this, with the animal continually biting and waggling its tail, are indications of maggots. After they have been on a sheep for about twelve hours they will eat large holes out of the animal, and in twenty-four to thirty-six hours they will often kill it if not discovered.

These pests are most prevalent when hot sun follows rain, in damp, close, warm weather. When sheep are badly attacked by maggots they will often leave the flock and hide in such secluded spots as unused quarries, brakes, cliffs, or any wooded places, and are sometimes very difficult to find.

The best means of prevention are, to dip the sheep through the summer, especially lambs; keep them perfectly free from dirt, as nothing attracts blowflies quicker than dirty tails; in drafting, cull all ewes that have had maggots badly, and never use

a ram that has had them. The writer has known several instances of maggots being reduced to a minimum in a flock by carefully carrying out the last-mentioned means of prevention.

Notwithstanding all this good management, maggots will occur more or less in the best-regulated flocks. So here comes the question, " What is the best cure ? " On this point shepherds are not agreed. In selecting a cure there are two points to be considered ; something is wanted that will be effective in removing or killing the maggots, and, at the same time, do least harm to the sheep, or growth of the wool by its application. Paraffin oil, for instance, will soon clear the maggots, but, at the same time, will very seriously injure the growth of the wool. Other ointments are made up which do the wool very little harm, but are not so effective in getting rid of the maggots, and certainly their extermination should be the first point to be considered.

A strong solution of McDougall's carbolic sheep-dip is often used for this purpose with very good results.

Some shepherds use the mercuric pencil.

If the wool is short the pests may be removed by putting on air-slaked lime, and rubbing it in with leaves from a foxglove. These maggots cannot put up with anything so dry, and quickly throw themselves off.

In exceptional cases sheep get badly eaten, the maggots break the skin and make large holes. In a case of this kind they should be taken out of the holes with a small stick or quill, after the wool has been shorn around, and a little beyond the affected place, very closely. The body of the sheep should then be well dosed with powdered air-slaked lime, for two or three times a day, until the flies give up irritating the sheep. In such a case as this, some people use Stockholm tar, but we much prefer the powdered lime ; it heals the wound quicker, and the wool grows better after it.

In the case of a sheep getting maggots before being shorn, the best plan will be to clip it, and dress with powdered lime. The part of the fleece damaged by the maggots should be pulled out and washed, whilst the remainder may be bound like an ordinary fleece.

Management of Hoggs.—These may all run together until the ones to be fattened are picked out for that purpose. At that time, a few more of the best gimmer hoggs should be picked out than will be required to replace the ewes drafted from the flock in the following autumn. The hoggs will then be divided into two lots, the fattening tegs and gimmer hoggs.

The fattening tegs are usually pushed forward in order to get them fit for the butcher about Christmas, or as near afterwards

as possible. The management of these sheep will vary a little under different owners, each one as a rule adapting his management to suit slightly different circumstances.

We will suppose that they have been liberally kept with continual change, since weaning, until the end of August or September. This is sometimes considered the most critical period of the hogg's life. Great care should be taken that they are not allowed to graze on damp, badly drained pastures at this time. When allowed on such fields they usually get bad attacks of "lung worms" and "liver flukes."

If there is any rape, they should be put on it, but not too suddenly, just a few hours at a time for the first few days. When they get accustomed to their new food they may be folded on it altogether. In the last folding of the rape there should be some turnips, so that they may learn to break them before being folded on them altogether. In the case of their not being on rape they should have a few loads of roots spread on the grass land, in order that they may be accustomed to them. When they are first folded on roots they are often allowed to run on grass by night for the first week. If there happens to be a suitable grass field on the other side, they may often easily be taken through a gap in the fence.

The fencing consists of hurdles, or posts and netting. The hurdles are usually made of wood, but in some cases iron ones are used. They stand about three feet six inches high when in the ground, and are from seven to eight feet long.

Iron hurdles on wheels are sometimes used. They are very expensive, but convenient on arable farms in summer time; when the ground is hard, it is awkward for driving in wooden hurdles.

Formerly the netting was made of rope, but of late years the wire netting has become almost universal in folding districts.

The posts on to which the netting is fastened are about four feet six inches, before being driven into the ground; the distance between the posts is usually about three or four yards. The rope netting is simply fastened to the post by string; for the wire netting two crooks are driven into the post—one at the top, which is turned up, and another the width of the netting lower, which is turned down. The netting is then fastened to these crooks by a top and a bottom mesh, and hung towards the sheep, the posts being on the outside.

The fencing should be put up in a straight line. The holes are made with an iron crow-bar, and the posts or hurdles are then driven in with a heavy wooden mallet.

The size of the breaks in different districts vary very much: some people go to the trouble of shifting the hurdles every

day; usually sufficient ground is fenced off to keep the sheep from a week to a fortnight. When the turnips get eaten well down to the bottom the hurdles are lifted. The fencing is then put forward so as to give a fresh break. In some cases the sheep are allowed to come back over the old break as well. Where store sheep are kept, the fattening hoggs are kept forward, and the stores follow them on the old break; they clean up the shells better than the fattening hoggs would do. Young sheep usually have to break their own roots until Christmas. The white and yellow turnips generally last until this time.

Young hoggs often fail in their teeth after Christmas, and as the swedes are much harder than the yellows, they are generally put through the turnip-cutter, and given in troughs. This makes a great deal more labour; but the sheep do better, as in some cases they have great difficulty in breaking the swedes. Another point in favour of cutting swedes is, there is far less waste, no shells being left behind. In the north of England, where there is a chance of the roots being injured by frost, this practice is almost universal. In order to save labour, and get an even distribution of the manure, the roots are put up in small heaps in rows across the field, and are covered with old straw and soil. Swedes, when rested in this way, improve, and become more nutritious, as more of the starch gets converted into sugar, which is more digestible.

The rows of heaps are put at such distances apart as will make a convenient break. The fencing is placed quite close to the heaps, but on the fold side, and as one row gets finished the fencing is put on to the next.

A turnip-cutter is kept in the field, being placed by the side of the heap in use. Feeding-troughs are kept in the fold, close by the cutter. The cut roots are carried from the cutter to the troughs in swills, two or three times a day. If the troughs are kept too long in one place, the ground around them gets very muddy and bad for the sheep; for this reason, it is advisable not to have the heaps of swedes too large.

Sheep on roots should be supplied with fresh straw, or hay in covered racks; they will consume very little until the weather gets severe. The more dry food they eat the better it is for them, as turnips alone make far too watery a diet. When first put on roots they consume about a quarter of a pound of hay per head, but in severe frosty weather they may eat three or four times that amount. Many writers put a great deal more than this, but our experience goes to prove that, when hoggs are supplied with plenty of turnips they rarely exceed three-quarters of a pound of hay per sheep per day. In a case where they are only supplied

with a limited amount of roots, they will, of course, eat more straw or hay.

If sheep are required to go off fat fairly early, it is necessary to give them a supply of artificial food, such as crushed oats or barley, bean or pea meal, cotton or linseed cake,—all, or some of these, may be mixed together. They should have only a few ounces per head given at first, until they get accustomed to eating it, when it may be increased to three-quarters or one pound per day. Some people give as much as one and a half pounds per day, but when feeding stuffs are high, and mutton low, the practice is not to be recommended; we think, however, that an allowance of three-quarters of a pound per day may be given and prove remunerative.

If a sheep were fattening for twenty weeks, and started on artificial food at the rate of a quarter of a pound per day, and finished with three quarters, it would just consume five stones during the twenty weeks; this would cost 5*s.* at £8 per ton. The sheep would be fatter, heavier, and better in appearance than others that had received no artificial food, and would generally fetch the extra cost of five shillings per head. Besides this, there are other advantages gained by the use of a little artificial feeding. The land would be enriched; the manurial value of the food, at, say, £2 per ton (about half Lawes and Gilbert's valuation), would come to 1*s.* 3*d.* per head. Another thing to be considered is, the addition of the artificial food would make a better-balanced ration, and this would tend to reduce the fatality in the flock, as less deaths would be likely to occur than if fed entirely on roots.

Sheep should have a little salt sprinkled with their meal or hay, unless they have access to rock salt.

In the case of hoggs not being fattened and sold in time to plough the root land for barley or oats, they are removed to a pasture field, and if any roots are left they consume them with hay, corn, cake, etc., on the grass land. They are then shorn before going into the market, whilst when sold from the root field, at an earlier date, they are usually sold in their fleece.

We reckon, in this neighbourhood (Aspatria), that an acre of roots, about twenty tons, with a little straw or hay, will keep about fourteen crossbred hoggs (Cheviot and Border Leicester) for twenty weeks, after which they should be fit for the market. The quantity that these sheep will consume per day varies much with the weather and other circumstances, but from twenty to twenty-five pounds of roots with a little hay or straw may be taken as an average quantity.

Some farmers, instead of buying sheep to consume their roots,

prefer to take in other people's, at so much per head per week. From $4\frac{1}{2}d.$ to $6d.$ is usually paid per head per week, although in some seasons, when heavy crops prevail, the price falls as low as $3\frac{1}{2}d.$ to $4d.$, but this is unusual. Besides the roots, the farmer usually has to provide the sheep with a little fresh oat straw, and perhaps a little hay in the spring; this he reckons economical, as the more straw they consume the less roots they will require.

In some cases the farmer contracts to look after and feed the sheep, in others the owner has his own shepherd.

These turnip hoggs often go down: in such a case the sheep are bled, and, if fit, sent to the owner; if not, the skin alone is sent.

The two most common causes of death amongst these sheep are "braxy" and stoppage of the water.

It is the farmer's aim to keep as many of the sheep alive as possible, as he gets no pay for the keep of any that may go down.

Shepherding.—During the time these sheep are on roots, they will often require to have their feet pruned and dressed, as they sometimes get overgrown, and suffer from foot-rot.

The sheep should be visited not less than twice daily; if any appear to be doing badly, they should be watched. If an ailing sheep has any flesh on it, care should be taken not to let it die; if the chances of its recovery are small, it should at once be slaughtered. Sheep that die without being bled are no use as mutton, whilst many that are ailing from stomach derangements or stoppage of the water, if killed in time, will be perfectly good for consumption.

A sheep with gid or sturdy should be killed and sent to the butcher, unless it is very thin and there is a chance of removing the bladder safely from the head.

Cost of Feeding a Teg.—We will suppose the example to be from a Cumberland farm, and the lamb to be a half-bred Cheviot and Border Leicester, purchased some time in August and run on grass for six weeks before going on roots. The lamb might be bought for about thirty shillings.

	s.	*d.*
6 weeks on grass, at $3d.$	1	6
16 ,, on roots, 20 lbs. per day = 1 ton in 16 weeks, at $8s.$	8	0
16 ,, on straw and hay, $\frac{1}{2}$ lb. per day on average = $\frac{1}{2}$ cwt. in 16 weeks, at $2s.\ 6d.$	1	3
16 ,, on cake and corn, $\frac{1}{2}$ lb. per day on average = $\frac{1}{2}$ cwt. in 16 weeks, at $8s.$	4	0
	14	9

Supposing the lamb was seventy pounds living weight when purchased, and to have increased on an average two pounds living

weight, per week. $70 + (2 \times 22) = 114$ lbs., living weight: sixty per cent. of this may be taken as its dead weight. $114 \times \frac{60}{100} =$ 68·4 lbs., or 17 lb. per quarter, dead weight.

Dr.	Teg. £ *s.* *d.*		*Cr.* £ *s.* *d.*
To cost price ..	1 10 0	By 68 lbs. mutton, at 8*d.*	2 5 4
,, food consumed	0 14 9		
,, balance	0 0 7		
	£2 5 4		£2 5 4

The value of the manure left from the consumption of the different foods would be four shillings at half Lawes and Gilbert's valuation.

The above calculation can only be regarded as an approximate estimate. A farmer would do well to consume his crops at the prices stated, and get the manure value over. The fluctuation of the mutton market, as well as deaths in the flock, influence to a great extent both profit and loss.

Management of Gimmer Hoggs.—As before stated, these gimmer hoggs are usually separated from the wethers, when the latter are placed on better keep, in the autumn, for the purpose of getting them fattened. It is usual to feed all those that do not appear good enough for breeding purposes. The remainder are run on grass with a few roots during the winter, with perhaps a little hay, and in exceptional cases they may be supplied with a little artificial food, such as cake, crushed oats, beans, etc.

They are grazed through the next summer, and shorn usually in May or June.

In the autumn, all those that may be required to replace the draft ewes are selected for that purpose, and the remainder are sold for breeding purposes, being then shearlings, or "two-teeth ewes."

Breeding from Gimmer Hoggs.—Many farmers who keep the larger breeds of sheep allow the ram to go with these ewe tegs when they are about seven or eight months old, so that those holding the ram may lamb when about thirteen months of age. Some of these lambs are yeaned late, when they receive the name of "cuckoo lambs."

The mothers and their lambs should be kept on the best of keep, to get the lambs fat and keep the mothers in a growing condition.

These lambs, if fat, usually meet with a brisk demand towards the end of the fat-lamb season. Being small and tender, butchers will readily give a penny per pound more for them than for ordinary ones. It is the best plan to sell them fat in this way, as they do not as a rule stand the winter as well as older lambs; the

money that they make will usually buy larger lambs in a leaner condition, and better adapted for the purpose of winter feeding.

It is a disputed question as to whether this practice of early breeding is to be recommended. The ewes certainly have less chance of developing strong frames than those left another year before lambing. This mode of management is practised by many lowland farmers, who hold that the ewes become better nurses and experience less difficulty in lambing afterwards.

On arable farms these "ewe tegs" often follow on the old folds after the fattening sheep.

To complete the management of our flock for the year, we shall have to describe the two very important operations of "shearing" and "dipping." The reasons for leaving them until last are, that they may be more thoroughly grasped by the student, and perhaps prove less confusing than if mixed up with the general management.

Shearing.—This operation is performed in the spring and summer, the time varies with different classes of sheep.

Show rams and fat sheep are often shorn very early; when the weather is cold they have to be kept in folds or sheds for a time after being shorn.

The reason for shearing rams so early that are intended for showing, is to allow them to get a good growth of wool before the show season comes on. Some skilful workmen, by leaving long wool in some places, and clipping closely in others, can cover many imperfections that the sheep would otherwise display.

This practice of early clipping has lately been much put down by agricultural-show committees, who disqualify any sheep which can be proved to have been shorn before the first of April. Notwithstanding this stringent regulation, show rams are clipped long before this date, but they are well looked after and kept under cover during the cold weather.

Fat sheep are often clipped in April, and driven into the market directly afterwards; though many are not shorn until May or June.

The store ewes are usually shorn last, generally before weaning in the beginning of June. Some people who wean their lambs early prefer to clip the ewes a week or so after they have been weaned, as then the yolk rises in the wool, it weighs heavier, and is easier to clip. The wool is much drier when a ewe is suckling her lamb; in fact, when a single lamb has been only sucking from one side, the wool is drier on that side than on the other.

There are many different modes of shearing. In one way the sheep is placed on a stool, in another the man stands in a pit.

Both of these methods prevent stooping, to a great extent, but the work is usually very roughly performed.

The orthodox way of shearing, is for the man first to turn his sheep, and put it to sit up on its rump, and commence by taking a few cuts off the fronts of the thighs, so that the shears may be easier entered afterwards, when finishing each side. The head is then held against the thighs, the throat and breast is opened down, and the belly wool shorn off. (Some leave the belly until last.) The neck is then shorn down to the shoulders. After this, the position is slightly changed. The sheep's head is placed between the shearer's thighs, the right shoulder rests on the shearer's knees, whilst he keeps his right foot on the other side of its right hind leg to keep it in position, and also to prevent it from kicking. The left side of the sheep is then shorn down with the right hand, starting each cut at the underline and finishing at the back. When approaching the hind quarter, the animal is laid on its side, and the shearer gets on his knees, putting one foot over the sheep's neck to prevent it from rising. When the left side is finished, the sheep is set again on its rump, and the right side is shorn down with the left hand. When finished, a well-shorn sheep should appear to be in concentric rings, joining exactly in the middle of the back, and running very much in the same direction as the ribs. These rings should show no signs of unevenness.

When sheep are shorn carefully in this way, a man would shear from twenty-five to thirty long-woolled sheep in a day—that is to say, if he had to catch his own sheep and bind the fleeces.

As a rule, about three men shear, and they have a stout lad to catch the sheep and bind the fleeces; in this case they would shear about four times as many as one man, or from one hundred to one hundred and twenty sheep per day.

Farmers who keep the larger breeds sometimes let their flocks to be shorn. In some districts twopence per sheep is given for catching, shearing, and binding the fleeces; 3*s.* 4*d.* per score is a common price.

When lambs are clipped they should be shorn early, in order that they may get good coats by winter. Some farmers leave the belly wool on, and clip the rest. The price for clipping lambs is usually from 2*s.* 4*d.* to 2*s.* 6*d.* per score. They are not usually clipped so closely as older sheep; their wool is much harder to cut.

When large flocks of sheep are kept, as on hill farms, the shearing is done in a very much rougher style, and, instead of the sheep appearing in even rings, broad uneven stripes from shoulder to rump usually prevail. With these small sheep and rough shearing an experienced hand will clip fifty in a day.

There is a deal of knack in tying up a fleece. Some men bind them neatly and tightly, others untidily and loosely. Any dirty locks that may be on the fleece should be pulled off, and thrown in a pile kept specially for that purpose. The ground should be perfectly clean and free from straw. The clean or cut side of the fleece is then thrown on the ground; the two sides are turned in, and should overlap in the middle. It is then rolled tightly from the tail end to the neck. A portion of the neck wool is drawn out, and twisted without separating it from the fleece; this forms the band, and is passed round the middle of the rolled fleece, and, when once round, the end of the band is turned in, to keep the fleece secure. By this means only the inside, or clean part of the wool is seen, as what was the exterior of the fleece on the sheep is turned inside before lapping the fleece.

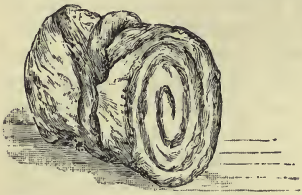


FIG. 91.

Sheep should be fasted for a few hours before being clipped. When full, they are very uneasy and troublesome for shearing, and therefore liable to get cut. It is a good plan to have a few in a large loose house overnight, to commence with in the morning. As soon as they are finished they may be turned out to feed. This will allow time for fasting, and drying the wool, of those brought in to be shorn on the same morning.

Cutting the sheep during clipping should be avoided as much as possible; when such an accident does take place, a little Stockholm tar should be put over the place with a stick,—this will keep flies from irritating it.

In shearing young ewes for the first time, particular care should be taken not to cut the teats, which are often small, and closely surrounded with wool.

When shearing is done under cover, the sheep should be placed on packing or bags, which should be kept perfectly clean. By far the best place for shearing is on grass; it is free from straw and dirt, and the sheep has a more comfortable resting-place than when on wood or stone floors.

For colonial purposes, where very great numbers of sheep have to be shorn, a most excellent invention was brought out, and shown at the Royal Agricultural Society's Show held at Doncaster in 1891, by "The Australian Shearer Company." This, in its action, is very like an ordinary horse-clipping machine, and is known as the "Compressed Air Sheep Shearer." The machine is worked by compressed air, which is conveyed to the machine by means of

flexible tubing, which permits the operator to work in any position. A small engine, or other motive power, is required to work the air-compressor, and to drive the air into the air-receiver. The machine is, of course, only useful when shearing is done on a large scale. An unlimited number of workers can go on at one time, whilst only one skilled man is required to look after the whole machine. The sheep are quickly clipped, and the wool is taken off in an even manner all over the sheep.

Washing.—It is a disputed point as to whether washing is necessary before clipping or not. We are inclined to think that sheep kept on grass should be clipped without being washed. The wool makes less per pound, but the fleece is heavier than a washed one, and balances the difference, without having the trouble of washing.

On the other hand, where sheep have been folded on roots for the winter, we recommend washing, otherwise the fleece will contain an undue proportion of dirt, besides being bad for shearing.

The operation is performed by taking the sheep to a stream or river side. They should be allowed to stand for an hour before being put into the water, as they might be over-heated at first, consequently there would be a risk of their taking a chill after the cold bath. It is also unwise to cast a sheep into cold water on a full stomach.

Two men throw the sheep over the bank into fairly deep water; by putting one hand each under the neck and joining the other two under the belly, the sheep is dropped in tail foremost. It is then allowed to swim until it gets perfectly soaked; the natural yolk in the wool, containing so much potash, acts as a soap. The sheep is next moved to a shallow running part of the stream, near at hand, where it gets its back and belly well washed, and a general finish.

They should, if possible, be allowed to run on a clean pasture for a week or so after washing, in order to allow the yolk to rise; otherwise the wool is dry for clipping, and not inclined to weigh so well.

Dipping.—If any one could see the lambs whilst being clipped in the south-western counties of England, they would fully conceive the advantages of dipping. If the ewe and her lamb be shorn at the same time, it will be seen that the latter will be infested with ticks to about twelve times the extent of the former. In the case of the ewes being shorn before being weaned, the ticks and lice that they have will leave them, and pass to increase the number of the unfortunate lambs. When lambs are not shorn, as is generally the case, they are even worse off than those that

are, as the latter often get rid of a proportion of these parasites during and after the operation of clipping.

This population of ticks and lice causes a great deal of irritation and uneasiness to the lambs, and thus very much retards their growth and fattening, if allowed to remain on the host.

We have known farmers, having only a few sheep, neglect dipping their lambs, not caring to go to the trouble, and perhaps expense, for such a few. This, of course, is shortsightedness; it is, however, encouraging to know that these careless men are far in the minority. Although there are, perhaps, many who neglect dipping their older sheep, still there are few who omit to dip their lambs, at least once during their existence, excepting those sold to the butcher as fat lambs.

It may be well to note what these unfortunate lambs, that are not dipped during the autumn, have to go through during the winter. These parasites cause a considerable amount of irritation, and consequently the sheep bite at the irritated parts; in doing so, they often get their wool entangled between their teeth, and, when the wool is particularly strong, the head is held in this position of biting, in consequence of the wool not giving way; so the poor sheep may be going round the field for hours with its mouth fastened to its shoulder, until some one comes to clear it. The teeth get very much loosened, and in some cases broken off. In other cases the sheep may be seen hopping round the field on three legs, owing to one hind foot having got entangled in some clots of wool in the neighbourhood of the shoulder. It is about the shoulder that these parasites mostly abound, especially in the case of lice. In the months of December and January these undipped hoggs will often be seen with bare patches on the shoulder, in consequence of their continual biting and scratching with their hind feet in order to try and free themselves of these pests. If the mouths of these sheep be opened, the teeth will be found, either broken, or matted up with wool so tightly, that it is sometimes hard to cut it through with a knife. All these things must materially interfere with the well-doing of the sheep. In some cases, when the wool has been swallowed, it forms into balls, and may cause the death of the sheep.

From these remarks it may be seen that, as regards both wool and mutton, there is a great economy in dipping lambs. For the same reasons, in a less marked degree, it will be found economical to dip older sheep, at least once during the year.

When only dipped once, it should be done in September or October; and the dip should be of an oily nature, as it then protects the sheep and wool from wet, besides destroying the parasites that may infest the animal. This is known as the "autumn" or

"winter dip." The "summer dip" is also used for killing these parasites, but more particularly for stopping the blowing flies from producing maggots. The lambs should be dipped in this about shearing time. Many farmers dip their ewes in it as well, about a month after they have been shorn (as soon as they have wool enough to hold the dip), to prevent them getting maggots during the busy time of harvesting. This is only a temporary operation, and they should be dipped again in October.

Some careful flockmasters think it necessary, or advantageous, to dip three times; when this is done, the first operation takes place in February or March, with the summer quality dip. It is supposed to have a beneficial effect on the wool, besides stopping the ravages of the blow-flies.

To secure the full advantages of dipping, the precaution should be taken to select a time when the sheep are perfectly dry. When the wool is wet it will absorb much less of the liquid, and consequently the operation will not be so effective as it should be.

On all farms where large flocks are kept, there should be a conveniently-constructed dipping-place. A glance at the rough sketch below will give an idea as to how such a place may be constructed.

The sheep to be dipped stand in the pen D, and are brought

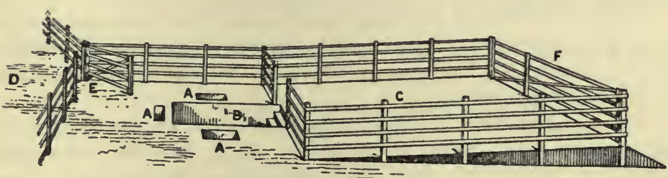


FIG. 92.—A, A, A, manholes; B, bath; C, drainer; D, sheep-pen; E, inlet gate; F, outlet gate.

one by one through the gate E. A man stands in each of holes A, A, A. The sheep is put, tail first and legs downwards, into the bath B, containing the dipping-liquor. The man at the end hole holds the sheep's head out of the liquid whilst the two at the sides rub the dip well into the skin and wool. After the sheep has been suspended about twenty or thirty seconds in the dip, it is turned up the steps leading to the draining-pen; here some of the liquid runs out of the wool, as it is left for some time to drain in the pen. The floor of the draining-pen is lowest in the middle, slanting from each side, and on an incline towards the dipping-bath, so that all the liquid that drains off, may run back again to the bath. The bottom of the draining-pen, as well as the

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bottom and sides of the bath, are laid with cement, to prevent any of the liquid being lost by absorption.

The draining-pen is sometimes divided into two. In this case the sheep pass into the first pen, until it is filled, and remain there to drain whilst the second pen is being filled.

On small farms, where only a small flock is kept, wooden dipping-tubs are generally used, but these are not nearly so convenient, for the following reasons:—

(1) The sheep have to be lifted up and put into the tub, instead of just being dropped into the bath, which is just level with the ground.

(2) The sheep, instead of being in a natural position, have to be put on their backs. When dropped into the well with their feet down, the wool has a tendency to float, consequently the dip gets free admittance to the skin, and the fleece gets quickly soaked. Also the legs and feet get a thorough soaking, this being a preventative against foot-rot.

(3) As the draining-pen is much smaller, more trouble has to be taken in squeezing the superfluous dip from the fleece.

In some elaborate arrangements a dropping platform is suspended by pulleys and weights; the sheep is placed on this, and dropped into the dip in a standing position.

Great care should be taken in choosing dips, as some contain large percentages of arsenic and sulphur; these are poisonous, and, although they are very effective in destroying the parasites, they often injure the wool.

Cases have been known where the use of such dips has been the cause of death amongst the flock, besides occasionally poisoning cattle that may happen to be grazing on the same pastures, through eating grass with some of this poison on it.

McDougall's non-poisonous dip is now in great request amongst flock-masters; there are several others which are also almost as popular, such as Cooper's, Biggs's, Little's, Campbell's, and several others.

Some farmers prefer to mix a proportion of poisonous with McDougall's non-poisonous for summer use, as they hold that the mixture is a better preventative against maggots than McDougall's alone.

When any poisonous dip is used it should not be applied to ewes suckling lambs.

In the case of dipping to prevent or kill scab mites, the solution should be made nearly double the usual strength, and the sheep kept in the solution for double the time. They should undergo another operation about three weeks later, in order to

kill any mites that might have been out of reach at the first dipping.

The most important constituent in McDougall's dip is carbolic acid. It may be purchased in small lots in canisters, in drums containing about twenty pounds, or in casks containing from fifty to two hundred pounds. In the ordinary way ten pounds is sufficient for about fifty sheep. It is dissolved in hot water, and then cold is added—so as to make about one gallon of dip for each sheep. The cost, including labour, comes between 2*s.* 6*d.* and 3*s.* per score.

Pouring is sometimes done; it consists of opening the wool with the fingers, and pouring the solution on from a can with a long spout (a watering-can without the rose does very well). The solution is made about four times the strength of the usual dip, and about one quart to a sheep is used.

Smearing or Salving is still practised in some parts of Scotland. It consists of smearing the wool with a mixture of rancid butter, grease, and Stockholm tar, or ordinary dipping composition in concentrated form. It is supposed to protect the fleece from rain. The practice is chiefly confined to hill farming.

Striking.—Some people strike their sheep over the back and sides with powders. This practice is not to be recommended, as the powders used chiefly consist of sulphur, which has an injurious effect on the wool.

Sheep on Purely Arable Farms.—Unless the leas are allowed to remain down for some time on these farms, the sheep have to be folded almost all the year round. In such cases a great variety of crops are grown; a part of the fallow as well as some of the corn acreage, is cropped with forage crops, in order to provide food at different parts of the year. The rotation is often very complicated, being made to suit differing circumstances. In many cases it would not be advisable to pursue any regular course, as it is often best to break a bad layer before its time; whilst, with such a crop as lucerne, it would often be advisable to allow it to remain down an extra year or two, if it continued to keep clean and produce good crops.

Such crops as the following are usually grown on such farms. Rye, trifolium, vetches, lucerne, sainfoin, rape, mustard, thousand-headed kale, cabbages, kohl-rabi, besides the ordinary roots (white and yellow turnips, swedes and mangolds.)

Rye, vetches, and trifolium are often grown as catch crops, having roots taken after them. Lucerne and sainfoin, being perennials, are often kept down for some time.

Sheep being folded on roots so much on these farms, have a tendency to fail in their teeth earlier than grazed sheep.

"A Flying Stock."—This system, of keeping a flying stock, consists of buying in ewes during the autumn and tupping them; they are usually sold with their produce during the following spring or summer.

Draft ewes are usually bought for this purpose, and are often crossed with rams of other breeds for the purpose of producing fat lambs. The lambs are sold to the butcher early, and the ewes fattened off.

Another way is to sell the ewes with their lambs by their sides in the early summer.

This system is a good one on damp farms, where sheep are subject to "fluke," because the sheep are fattened before the pests have the chance of doing much injury. If the sheep were kept for two or three years on the farm, the death-rate in some seasons might become very serious.

Hill Farming.—The management of sheep on a hill is rather different and less liberal than on a lowland farm. On these farms only the smaller, more active, and hardier breeds are kept, such as the Scotch Blackfaces, Cheviots, Herdwicks, Welsh, Exmoors, and Lonks.

The ewes are usually tupped in November, one ram being selected for every sixty or eighty ewes. They then lamb in April.

They run on the hills all winter, and are often supplied with no other food beyond what they pick. In some cases, however, they receive a little hay during severe snow storms, and, if any is available, they get some a few weeks before lambing.

The lambing is arranged to take place late in the season, in order that there may be a chance of getting fresh keep soon after the lambs are dropped, otherwise the mothers would have little chance of maintaining their offspring. Another reason for late lambing is, that, as the mothers have to lamb on the hill, it would be unwise to expose them during lambing to the severe weather earlier in the season.

In backward springs they often get their lambs before there is any food, consequently great losses occur in the flock during such seasons; in some cases the keep is so scarce that the lambs have to be killed in order to save the lives of the ewes.

The ewes and lambs run together on the hills until the autumn. The lambs are then usually brought down. The *wether lambs* are sold to lowland farmers to feed on roots, etc.; or else wintered on the lowlands, and sent to the hills again in summer, being kept there in some cases until they are two or three years old, when they are sold, either to the butcher or the lowland farmer, to be fattened on roots.

The *gimmer lambs* are either sent away to winter, or otherwise kept on the low-lying land, where they are usually given a little hay during winter; they return to the hills the following summer, and the best are selected to supply the place of the "draft" or "cast" ewes in the autumn.

The ewes are drafted at four or five years old; they are often purchased by lowland arable farmers, who feed them off on roots.

In many cases where it is the custom to sell off the lambs every year and only keep the ewes on the hills, these ewes are crossed with a "bred" tup, such as a Border Leicester, Lincoln, or Oxford Down. In such cases a certain number of the ewes are put to a ram of their own breed, in order to keep up the number of pure-bred ewes.

In many cases half-bred ewes are bred from. The object in crossing, or using a ram of a larger breed, is to improve the size of the lambs, as well as giving them a tendency to come early to maturity.

House Lambs.—It has been mentioned that Dorset ewes often lamb in October, so as to produce fat lambs for the Christmas market. These are usually known as "house lambs," owing to their spending some time of their life in a house. It may, however, surprise our north-country friends to hear that, in favourable winters, many of these lambs are reared and sold fat without having spent a quarter of their nights under cover.

In order to get a good supply of nutritious keep, to produce a good flow of milk, some of the cleanest of the wheat land is seeded with Italian rye-grass. This will, as a rule, produce more autumn keep than ordinary seeds. It can be fed down quite bare, and the stubble may be cultivated in plenty of time for the succeeding crop. Besides this rye-grass, there should always be some rape and early turnips ready for these ewes and lambs.

When the lambs are about a month old they may be folded on turnips, and the males castrated. The turnips are often sliced for the ewes, and put through the cutter a second time for the lambs, so as to get them in small pieces. Lamb hurdles are used, so that the lambs may be fed in advance of the ewes. They get a supply of cake and meal with a slight sprinkling of salt; besides this, they can get a little of the best meadow hay that can be procured for them; the hay they leave is given to the ewes. Both the hay and meal should be given to the lambs in covered racks and troughs to prevent it getting wet.

For producing these early lambs, it is usual to pick old ewes which have been gradually brought to lamb earlier every year. In order to get them in season early they receive a bountiful

supply of vetches, trifolium, etc., just before the required time. The ewes are generally fed off with their lambs, by giving a supply of cake and meal in addition to their turnips and hay, getting from half a pound per head per day to a pound and a quarter to finish with.

In order to get the flesh firm, it is necessary to give a proportion of bean meal during the last period of fattening. In bad weather they are taken off the turnip land, and get the same food on pasture.

As a rule they require very little more shelter than is afforded them by the peculiarly constructed hurdles, named "wattled hurdles," seen in Dorset, Somersetshire, and the neighbouring counties. Instead of being open like an ordinary hurdle, they are of a basket-work construction.

These fat lambs make an enormous price in the beginning of the year; some are fit for the market at ten to twelve weeks old.

D.—*Breeds of Pigs.*

Amongst the most popular breeds of pigs are the Large, Small, and Middle White breeds of Yorkshire and Lincolnshire, Berkshires, Tamworths, and Suffolks. Besides these, there are many

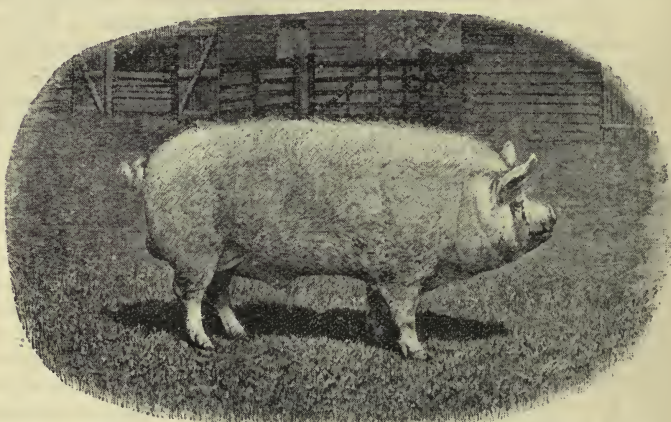


FIG. 93.—Large White Yorkshire boar, "Holywell Windsor;" bred by Sanders Spencer, Holywell Manor, St. Ives.

other local breeds which have usually been very much mixed and crossed with others.

The **Large Whites** are a great improvement on the old large and coarse breeds of Yorkshire, which were originally coarse

boned, long limbed, low shouldered and narrow backed. Bakewell is generally supposed to have been the first great improver of this breed, meeting with the same marked success in this case as he did with the improvement of the Leicester sheep and Longhorned cattle.

The original breed were slow feeders, but when they reached maturity they made very great weights, from sixty to sixty-five stones (imperial), dead weight, were often scaled.

The improved breed are very fine pigs, and are widely distributed. The head is fairly large, ears overhanging. The body is large, shoulders full; back, as a rule, level, but sometimes arched; the hind quarters slanting towards the tail, and legs fairly large.

They are fairly prolific, and carry a good proportion of lean in comparison with fat flesh, consequently make good bacon hogs. Under good management and feeding, they often weigh from twenty to twenty-five stones (dead weight), at twelve months old.

The **Middle Whites** are smaller than the large, and larger than the small breeds. They are not so uniform in size and appear-

FIG. 94.—Small White Yorkshires; bred by Sanders Spencer, Holywell Manor, St. Ives.

ance as the other two breeds, but, as a rule, they approach nearer the form of the large white than the small. They are an excellent breed; the pork is of very good quality, and they come early to maturity. The sows are fairly prolific, and are very good nurses.

The **Small Whites** (Fig. 94), like the others, are very widely distributed, but on the whole are not such favourites, as they have a tendency to lay on a large proportion of fat to lean flesh. They are supposed to have inherited this quality from the Chinese pig, which was used to improve the original breed. They are more delicate than either of the other breeds, and the sows are not very prolific. In fat pigs the eyes are often invisible, although they should appear large in store animals. The forehead is flat and broad, the snout short and upturned. The ears should be small and slightly inclined forward, but not drooping, and set widely apart. The chops, or jowls, should be very full and large. The neck is very full and heavy, shoulders wide. The ribs are well sprung and the loins are wide. The tail is set rather high. The hams are large, the meat being well let down to the hocks. The proportion of offal is small.

These pigs are often used for crossing with others which have less tendency to put on fat; for this purpose they are very useful, as they usually improve the quality of the meat in such cases.

The **Berkshires** are a very old-established breed, and have many admirers. It is generally supposed that the old breed has been improved by the introduction of Chinese and Neapolitan

FIG. 95.—Berkshire sow.

blood, but many of the Berkshire breeders dispute this statement, and contend that they have been improved purely by selection from the original breed.

They are a black breed with white points. The black is often tinged with red, and not so coal black as the Suffolks. They usually have a little white on the nose and forehead, four white

feet, and end of the tail white. Head is moderately short, forehead wide, nose usually straight, ears slightly projecting, sometimes covering eyes. Chops full, eyes usually bright and large. Good muscular neck ; fairly good shoulders ; ribs often rather flat, but not always ; very strong over the loins, but the hind quarters are often short and droop too much. The underline is not so even as in some other breeds. The legs are short.

The amount of hair these pigs carry varies much with different management. When allowed to run roughly they develop a great deal, but when confined and well fed, much less is to be seen. When deficient in hair they are usually considered to be a little delicate, but those carrying too much, of a coarse and bristly nature, are usually coarse fleshed, and slow feeders.

These pigs are well adapted to rough treatment, or to act as scavengers on the farm, when they have to find most of their own living, in the yards, fields, or forest. For this purpose the rough-haired ones are usually best, being stronger in constitution ; whilst the finer specimens are often faster feeders, and best adapted for making pork under more liberal treatment and confinement.

The strong point about the Berkshire pig is, that the pork has a large proportion of lean to fat meat, of excellent flavour.

The **Suffolks** are a very black breed with plenty of fine hair. The forehead is broad, the nose short and slightly turned up ; the ears are short and hang rather forward ; the chops are full ; the shoulders good ; body long ; tail set high ; the legs are short, with the meat well let down to the knees and hocks. They are very quiet, less inclined to range than the Berkshires, when kept in fields. They are not large eaters, nor very fast growers, but are easily kept fat, and, when properly fed, produce plenty of lean meat. The sows are fairly prolific, and good nurses.

The **Tamworth** pigs are, comparatively speaking, a new breed, and until lately were not much known out of their own county (Staffordshire), but during the last few years they have become widely distributed, as many breeders of different districts have purchased a few in order to test their merits with other breeds.

As might be expected, this breed is not quite so uniform in character as some of the other breeds ; but as their best points and qualities become more stamped by the judges in the principal show yards, their breeders will know more definitely what to breed for. Their colour varies from red to brick colour. The head is comparatively small, with a rather long straight snout ; ears drooping rather forward. The body is fairly long and deep-sided ; the legs are sometimes rather long, but they have good hams, the meat being well let down to the hocks.

They have plenty of lean flesh in proportion to fat, consequently they are great favourites with bacon-curers. They are also well adapted to cross with other breeds that are inclined to run too much to fat.

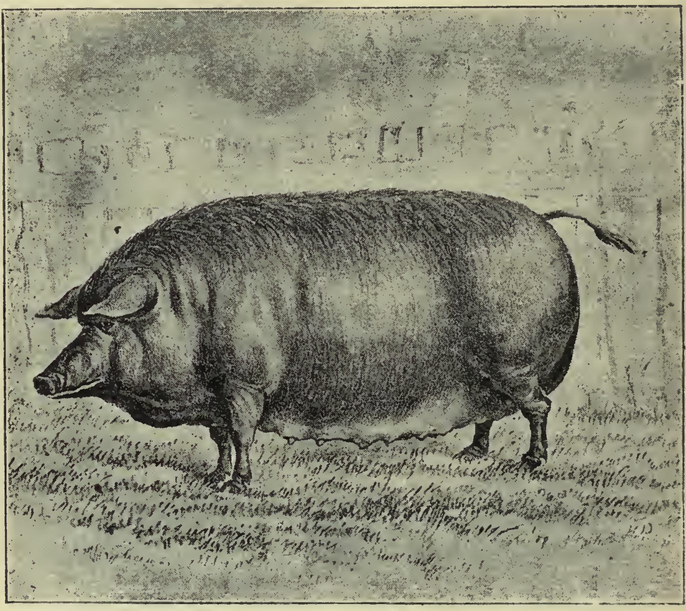


FIG. 96.—Tamworth sow

They are prolific, hardy, and come early to maturity, making good weights.

The breeds that have been described are the principal ones; but, besides these, there are some local breeds which have become adapted and suited to the different requirements of different localities. Under this class the "Large" and "Small Blacks" perhaps should be noticed. These two breeds are found in considerable numbers in Devon and Cornwall. The "Large Blacks" are very long-sided, and large pigs with black coats. In form they are not unlike the Tamworths. The head is rather small, with long and straight snout, with the ears lapping over the eyes. The long lapping ear is considered a strong point for denoting purity in the breed, as, when crossed with the Berkshire, as they often are, they develop pricked ears. They are fairly

wide over the shoulders, and deep sided; the back should arch rather than droop. They are inclined to be a little higher on the hind than the fore quarters.

The average litter may be taken from ten to twelve. The sows are fairly good nurses.

The "Small Blacks" are slower feeders, smaller consumers, and cost much less to keep; but still, where there is plenty of food, they are considered less profitable than the large breed. They have short snouts; small ears, coming a little forward; low and round in the carcase; good constitutions, but less prolific than the "Large Blacks." They are probably a variety of the Suffolk breed.

Management of Pigs.

On almost every farm, pigs form a more or less important part of the live stock. Their management, however, varies very much according to different circumstances of farming. In some cases they may be fed and sold as porkers, or kept for bacon hogs; sometimes sold as stores from ten to sixteen weeks old; and sometimes kept as scavengers, to pick up just what otherwise might be wasted.

Before selecting any particular breed, the farmer should consider the merits of each, and choose from those that would be most likely to prove profitable under the circumstances that he would require them for. In a case where they would be required to find the major part of their own living from the grass, fallows, and waste foods, the Berkshires, Suffolks, and Blacks would be very suitable. For close confinement and early feeding, the Yorkshires might prove more profitable.

The male animal (entire), after weaning, is called a "boar."

The male animal (castrated), a "hog."

The female is a "sow."

If spayed, a "cut" or "spayed sow."

A young uncut female, a "yelt" or "gilt."

A sow after taking the boar is said to be "lined." When she gets her young she is said to have "littered," and the young are "farrows" until they are weaned. If killed before weaning, they are known as "sucking pigs." After weaning, they are in some places called "slips;" when fattened at an early age, "porkers;" when kept for bacon, "baconers;" and when kept for store, to grow without fattening, "stores."

It is most important that only well-bred stock should be selected to breed from—a fact that is too often not recognized by the ordinary farmer. A little extra outlay in the first place, in order to procure well-got and good animals, will stand a far better

chance of being repaid with interest, in the case of pigs, than with any other class of live stock. Pigs being so much more prolific than horses, cattle, or sheep, the extra outlay is divided amongst a much greater number of young ones, and consequently more likely to be realized.

A good sow, with ordinary luck, will produce twenty pigs a year. Supposing these were kept on similar food to twenty from an indifferent sow, until both lots were three months old, as store pigs, the ones from the well-bred stock would probably fetch about 5*s.* per head more than those from the indifferent sow. This would mean £5 on the lot. If any were sold for breeding purposes, the difference would be still greater. We may conclude from this, that the extra outlay would be more than covered the first year.

In the case of sheep, in order to get twenty lambs, about from twelve to fourteen ewes would have to be purchased, consequently the extra outlay would be far greater, and less likely to be returned by the first year's produce.

Best Age for Service.—A sow should not be allowed with the boar until she is ten months old; neither should a boar be allowed to line a sow until it has reached that age. When pigs are bred from at too early an age they get weakened in constitution, and produce degenerate young.

Sows for breeding should, if possible, be selected from a spring litter, from a mother with good milking qualities, and they should not have less than twelve teats. The reasons for taking brood sows from spring litters are because they get the advantages of the summer weather, healthy exercise, and green food, which are more likely to encourage milking qualities and well-developed frames than when they are kept in houses in winter, during the early part of their lives.

When a sow wants connection with the boar she shows very marked signs—she becomes very restless, refuses her food, grunts a great deal, the vagina gets swollen, and, if allowed to run with other animals, will follow them.

A sow has two litters a year. They should be allowed to get their first litter in March. They will be ready then to take the pig again some time in May, and, as their period of gestation is sixteen weeks (they occasionally go a few days longer), they will bring their second litter early in September, just at the time there will be plenty of food, and will get fairly well grown before winter comes on.

After the sows have been served, during winter they should be allowed plenty of exercise in a roomy sheltered yard, where they may be supplied with roots, wash from the house, and a little bran

or tail corn, sufficient to keep them in good healthy condition. During summer they may be allowed to run on the pastures, or rape, or perhaps be supplied with clover, rape, vetches, or prickly comfrey in the yards. As they approach within a week or two of the time of parturition they should receive a little extra food, such as a little oat or barley meal, mixed in their wash, in order to produce a good flow of milk. The food should not be changed suddenly at any time near the date of farrowing, either before or after, as it might suddenly alter the character of the milk and act injuriously on the young animals.

The sow should be removed to the farrowing-house some days before she is expected to litter, so that she may become well accustomed to it. She should be provided with short straw for bedding, which would get well trampled down by the time she farrows. Fresh straw should never be given at this time, as the young ones might crawl into it and get lost.

The chief indications of approaching parturition are: the distension of the teats with milk, dropping of the pelvic bones, enlargement of the vagina, besides the sow collecting any available straw for the purpose of making her bed.

An attendant should always be present during farrowing, in order to see that none of the young stray away from the mother, as they sometimes will do, and die of cold and hunger in an opposite corner. The attendant should be some one the sow is familiar with (as the feeder), as with strangers she will be suspicious and very uneasy.

Houses used for farrowing should have a stout rail all round, about nine or ten inches from the wall and about a foot high. Heavy sows often lie on the young pigs and kill them. The rail acts as a preventative, as the little pigs are fond of nestling together by the sides of the walls or partitions. Consequently the rail protects them from the mother whilst lying down. The sow usually rests her back against the wall in order to let herself down gently.

As soon as the afterbirth, or cleansing, comes away, it should be removed and buried in the dung-pit or some convenient place.

After farrowing, the sow is usually very thirsty. She should be given some chilled food of a washy nature with a little meal in it.

In some cases sows are rather given to eat their young. If anything of the kind is suspected it is well to give them plenty of washy food for the first day or so, and more especially directly after farrowing, though in the ordinary way we do not recommend feeding heavily for the first few days.

Sows a day or so after farrowing often get very costive, and

require a slight purge, such as two or three ounces of salts (Epsom Salts) in their food per day.

Some young pigs lose their tails. This gives them a very awkward appearance, and for breeding purposes goes very much against them, a long and bushy tail being, as a rule, considered a point denoting constitution. This is often considered a result of "in-and-in breeding," and said by some only to occur in highly bred stock; but the writer's experience proves that it may be seen just as often in cross-bred pigs which have been bred entirely at random. Many other reasons have been given for pigs losing their tails. Winter litters are, as a rule, much more affected than summer ones. It may be prevented to a very great extent by rubbing the tails with goose fat or linseed oil. If they are examined, the tail in the early stage will appear slightly inflamed. This increases every day, until the end simply rots off.

The young pigs should always be kept warm, and free from draughts. After they are a few days old they should always be provided with good bedding.

The mother should be liberally fed whilst suckling her young. In winter time it is better if the food can be given slightly warm. Boiled potatoes, roots, and meal of different kinds may be given, besides washings from the kitchen. When the farrows get a week or two old, the mother should be allowed a run in the yard or field for a few hours every day. When they are about a month old they should be taught to take a little milk and corn; a little whole wheat is the best thing to start them with. They have very sharp teeth, and grind it up very readily when they once start. They should be given the grains whilst the sow is outside, in the middle of the day.

The males, unless required for boars, should be castrated when from four to six weeks old. Some people leave it until later, but we consider about a month old the best time, as they suffer and swell less at this age than when left until later.

The operation is very simple with a good knife or old razor. When the stone (testicle) is taken out free from the lining membrane, the string may be either cut or drawn. The little animal is then held up by the two hind legs, and a little water, in which some common salt has been dissolved, is poured over the incisions. It may then be returned to the house.

The females that are not intended for breeding purposes may be spayed. The operation consists of removing the ovaries, and should be performed about ten days before weaning, so that they may recover from the operation before the mother is taken from them.

Spayed sows feed much better than others; when they are not spayed they come in season. Whilst in this state they get very uneasy, and waste their food, besides disturbing other pigs that may be kept with them. Under such circumstances they naturally fall off in condition. If they are killed whilst in season the pork has a strong taste, and the bacon will not cure properly.

Some people prefer to wean young pigs at six, others at eight, weeks old. If pigs are strong, and started to eat at a month old, they will generally be fit to wean at six weeks. If they can be supplied with plenty of skim milk and kept warm, they will do quite as well without their mother as with her. When a sow is kept very much with a large litter between six and eight weeks old, she naturally gets pulled down in condition, and the extra amount of food she will require will be more than required for the young pigs if weaned at six weeks old. Should the young pigs be small, or the skim milk scarce, they should be kept eight weeks with their mother.

Weaning should be done gradually, so that the sow may not become overflushed with milk. One way is to let her be with the farrows just twice a day a short time before weaning, and only once later on. Another very good plan is to take some of the strong ones from her first, and keep the weaker ones on her a little longer.

When the sow begins to get litters that are not uniform in size or character, she should be fed. As they get old they often bring a few weak specimens, which are not worth rearing, and which in many cases die after a week or so old, when the others get strong enough to push them from the teats. In the south-western counties these small pigs receive the name of "nestle birds," in other places "wrecklings," etc. Some sows may be bred from much longer than others, but, as a rule, four or five litters will be quite enough to take from a sow. She should get her fourth litter at about three years old.

Some sows are much more prolific than others. Ten is a good average litter, and generally quite as many as an ordinary sow can bring up properly. Sometimes a sow may only get six or seven, whilst others get fourteen or fifteen, and even more.

It is often a good thing to get two sows to farrow as near the same date as possible. Then, if one happens to have a small and the other a large litter, they may be equally divided. A sow is not as a rule particular about having strange pigs put on her, if they are transferred soon after farrowing. In putting one sow's pigs on to another, it is a mistake to take the worst ones, if they are smaller than the ones they are going to mix with, as they will

probably be kept away from the teats by her own pigs. In such cases the strong ones should be taken, as the weaker ones would in all probability do better with their own mother. But if the weaker ones are older than those with which they are to be mixed, they may be selected, as they will probably be able to look after themselves.

The Management of Young Pigs

after weaning will vary very much with the different purposes for which they will be required.

When they are required to be kept through the summer as "stores," to consume the skim milk, whey, or washings from the kitchen, and run on the pastures, or get green food given them in yards, they would not receive a large allowance of corn or meal after weaning, but as much milk as could be spared. After running in the way described through the summer, they would be run on the stubbles after harvest to pick up any heads not collected. They are also fond of weeds and roots, such as couch.

In neighbourhoods where acorns are to be had, the store pigs will find a large proportion of their food in the woods. They should be given a little meal, or a few peas or beans at night, so as to bring them home regularly. After running cheaply in this way through the summer and autumn, they may be put up to feed, when they will probably make great progress on small or slightly diseased potatoes, boiled and mixed with a little barley-meal and bran, or any tail corn which may be boiled or crushed for them.

It is a common practice on mixed farms in the western counties, and probably in many others, to dispose of the pigs as "slips" at ten or twelve weeks old. With a good breed of pigs this system may be made to pay very well. The great secret in this system is to have the sows farrowing at the right time.

There is always a great demand for young pigs about April and May, just as the dairymen get in full working order with their cows. It is usually a good point to be early in the market with pigs which have the appearance of putting on flesh rapidly, having plenty of length. When intended for such a purpose they should be farrowed in February and well kept. It is an old saying that "half the breed of a pig goes in at its mouth," and certainly, after looking at a pig that has been meanly kept, and a brother from the same litter that has been well fed, we might be almost inclined to believe it.

After weaning they should get as much skim milk as could be spared, with a little mixed barley, oats, maize, and bean meal, first wetted with cold and then scalded with boiling water. This should be given at both ends of the day. In the middle of

the day they should get some whole grains of barley and wheat, with a little mangold-wurzel chopped up small. These whole grains they thoroughly grind up and masticate. They give them a good coat and a firm appearance, and prevent them from becoming puffed-bellied, as they do sometimes when too much cooked food is given. About two pounds of corn per head per day may be given, besides milk, etc.

They should be kept in a light sty, and have plenty of room for running about to exercise their muscles and develop their limbs. In the event of their being kept in a small house they should be put out in the yard for exercise every day, otherwise they may get stiff in their movements and appear delicate in their coat.

When these pigs are well managed, they will weigh from fifty to sixty pounds at ten weeks old without being too fat, and about the beginning of May such pigs would probably make from twenty-three to twenty-six shillings per head. They are often sold at the rate of sixpence per pound, living weight, when not exceeding fifty pounds per pig.

The second litter, which should be born about the end of August, will not usually sell so well; but they will come at harvest time when corn and roots are abundant, so may be kept fairly cheaply. These pigs, as a rule, will have to be sold to cottagers and people having gardens and small potatoes. Pig-jobbers can usually dispose of them round the countryside. They will probably be fit to sell at the end of October or the beginning of November, when a pig weighing about sixty pounds, living weight, will fetch about twenty shillings; or fourpence per pound, living weight. Should the demand for such pigs be small, owing to a failure in the potato crop or high price of corn, etc., it will often pay better to feed them off as "porkers," selling them, from four to six months old, to the butchers. Or some of them may be kept rather coarsely through the winter, and sold in the following spring as "stores," when the price gets up; or they may be run very cheaply through the summer and autumn as "stores," and will feed to large baconers during the following winter.

"**Fattening Pigs**," besides being supplied with the necessary amount of good food, require regular and systematic feeding, a clean and comfortable bed, and a warm sty. Some pigs are much more restless than others; those that lie quietly between their meals usually thrive best.

Fat pigs may be disposed of as "porkers" or "bacon hogs."

When intended for "porkers," feeding should be commenced directly after weaning. In winter time their food should be given

slightly warm. The farmers who usually go in for fattening porkers are those who have a supply of skim milk, butter milk, or whey, which, with an addition of meal of various kinds, produces excellent quality young porkers at four, five, or six months old, when they might weigh from seven to nine or ten imperial stones, dead weight.

In feeding porkers, only small quantities of maize meal or kitchen wash should be used, as these foods are apt to produce pork of a greasy nature.

Young pigs, after weaning, should at first be fed three or four times a day, and should get only as much at a time as they will finish. If they are given more at a meal than they can consume at once, in all probability they will get it dirty, and then refuse it: this will encourage them to waste their food, and, in a short time, pick out the best and leave the rest.

The trough should be kept perfectly sweet, and cleaned out, if necessary, before each meal.

When intended for baconers they are usually run as stores for twelve months or more on the coarser classes of food, such as grass, clover, roots, etc. They develop good large frames, and when first put up to feed are usually large consumers, and put on flesh very rapidly. During the first period, they should be kept on boiled potatoes, or roots mixed with a little boiled or steamed corn or meal. Their appetite will soon be reduced, and they will often become more particular and dainty as regards their food; consequently the boiled potatoes, roots, etc., should be reduced, and the meal or boiled corn increased. In some cases pigs will feed almost entirely on boiled potatoes and swedes; but, when fed in this way, the bacon is not of good quality—it lacks in firmness, and the fat is usually present in too large a proportion.

In order to get good quality bacon, with firmness and streaky appearance, and with a good proportion of lean to fat, great care should be exercised during the last three or four weeks of fattening; boiled food should be reduced, and be supplemented by mixed meals and bran, which may be scalded for a short time, a little salt added, and, if possible, be mixed with a little milk. Maize meal should be used only in small quantities, whilst pea and bean meals should be well represented in the mixture. It should, however, be remembered that, if bean meal is given in too large a proportion, it is likely to produce hard meat, instead of its being merely firm in character.

Old Sows, after they have produced four or five litters of pigs, are fed; they make good bacon and excellent hams when the latter are well cured.

The weights that these sows make when fattened vary very

much with the breeds and management, varying from fifteen to twenty score with the smaller breeds, and from twenty-five to thirty-five score with the larger ones (dead weight), and, in exceptional cases, even more than this.

Boars that are no longer required for service are often castrated, allowed to get thin, and then fattened. They make much less money than other pigs of the same weight, and are usually disposed of in mining or similar districts.

As pigs vary so much in size, the amount of food that they will consume will also vary. From one to two bushels of mixed meal or boiled corn are often consumed per head per week whilst fattening. When possible, cheap and second quality grain should be consumed by pigs. Barley that is not fit for malting purposes can often be obtained for less than three shillings per bushel, and is usually calculated, if boiled, steamed, or scalded, to produce an increase of about eleven pounds, living weight, or nine pounds, dead weight, for every bushel consumed.

Pigs will rarely be found profitable unless they are fed partly on food that is not marketable, such as waste from the kitchen, small and unsound potatoes, tail corn, whey from cheese-making, skim milk and butter milk which cannot otherwise be disposed of. They are exceedingly useful animals, being almost the only means of converting these waste materials into marketable produce.

Pigs make a greater increase of live weight for a given quantity of food consumed than either cattle or sheep; they also have a much larger percentage of carcase weight to offal when killed. The dead weight of a fat pig amounts to from eighty to eighty-three per cent. of its living weight. They will increase from eight to fourteen pounds in living weight per week, varying with size and management. In exceptional cases twenty pounds increase per week has been reached.

It is the custom in Berkshire to sour all food (especially milk) for pigs. For this purpose it is all mixed in large troughs (in which a little of the last-mixed food remains), and allowed to stand for some time before being given to the pigs, the idea being that they feed better on this soured food, and are less liable to suffer from costiveness.

When young pigs are kept in high condition on maize alone, they will often be subjected to staggering and fits. The writer has known many young pigs die from the effects of maize in this way; and when the food was changed for mixed barley and wheat, no more deaths occurred.

Maize is particularly low in ash constituents, and therefore

unsuitable for any young stock, unless mixed in small quantities with other more suitable foods.

In an experiment at Rothamsted, it was found that an addition of superphosphate of lime improved the feeding qualities of maize for pigs. Small coal and cinders are recommended by some feeders to be kept within reach; they are supposed to help in the digestion of their food.

Pigs are often kept by butchers, to consume the offal from the slaughter-house. They will also eat the flesh of dead animals, if allowed. Flesh is better for them when boiled. The pork from pigs fed in this way is not nearly so delicate in flavour as when they have been fed on grain, milk, etc.

Brood sows should not be allowed to consume any animal flesh, as it gives them a taste for eating chicken or young lambs, if they get the chance; it also may encourage them to eat their own farrows.

Pigs cannot be successfully reared on *whey* alone; but its addition to meal shows a marked saving in that substance. It has been calculated, from experiments, that when whey has been given to pigs, in the proportion of one gallon of whey to one or two pounds of meal, the gallon of whey has been equal to rather more than one pound of meal. The whey is chiefly valuable for the sugar it contains. When it is given in large quantities, the meal supplied in conjunction should be of a fairly nitrogenous nature, to get the best results.

The **Piggeries** should, if possible, be built facing the south, as pigs feed best in warm situations.

The ordinary kind of pigsty is built in the following manner. There is an enclosed portion for the pig to retire to for sleeping, etc., entirely built in with the exception of a little open doorway, large enough for the pig to pass in and out. When a man wants to enter the sty for the purpose of cleaning it, he has to stoop to get through the doorway. As a rule there is no door; but it is convenient to have a door fitted that slides up and down in a groove, in order that the pigs may be sheltered in very cold and windy weather during winter, although in the general way it need not be used at other times of the year. In front of the sty is built a little yard, which is usually slightly larger than the sty; the walls of the yard are low, so as to admit the sun.

The feeding-trough is usually built in the wall of the yard, with a swinging door dropping in it, so that the trough may be cleaned from outside. An iron bar drops from the door into the trough; this keeps the door from swinging beyond either side of the trough, and so prevents the escape of the pig through the hole, in which the trough is let in. The advantage of this

system is that the pigs may be fed without entering the yard. In some cases a stone flag is let down in the place of the door, but this, being immovable, does not offer the same facility for cleaning out the trough without entering the yard.

A special house or two should be erected for the accommodation of farrowing sows. These should be larger, and may be built without the yard, and usually without the trough let in the wall, as this may act as an inlet for too much cold air. It should be fitted with ventilators, which in severe weather might be easily stopped with straw, if necessary. It should have a stout rail all round, as before mentioned.

Some people prefer these closed sties for feeding purposes to those fitted with yards. A few fairly large sties, with yards proportionately large, should be erected for young pigs.

The ground on which piggeries are erected should be well drained.

Opinions differ very much as to which is the best material for flooring. In some cases asphalte is used. These floors are easily cleaned, and do not absorb the moisture; their slippery nature, however, makes them objectionable. Flagged floors are common, but many breeders object to flags, as they are apt to absorb the moisture, and are not considered good for young pigs.

Floors made of bricks laid in cement, or cobbled floors, are free from these objections, and are generally approved of.

In some cases wooden floors with small spaces between the boards are used, with the idea of saving litter. The liquid manure passes between the boards to a space below, the floors being swept out every day. The wood absorbs the moisture, and the liquid below soon gives off an objectionable odour. Pigs thrive much better when supplied with a warm, dry, and comfortable bed of straw. It is not, therefore, surprising to find that this kind of flooring has met with very few supporters in districts where straw is even only moderately abundant.

The floor should always have an inclination, in order to allow the unabsorbed liquid to run off, and keep the bed dry. Pigs, as a rule, thrive badly in a damp sty.

It is convenient to have a boiling-house near the piggeries, in which the food may be prepared and mixed. If water can be laid on to the sties and boiling-house, it will be found a great advantage.

E.—*Poultry.*

Poultry are among the lesser means which a farmer can employ to make a profit. As a rule they do not occupy a

prominent place among the stock of the ordinary English agriculturist, and it is somewhat rare to see in this country a farm, of any size, exclusively given up to the breeding and rearing of poultry. On the continent, however, poultry farming is often carried on with success by itself, and there is no reason why every English farmer should not make a good profit out of his fowls and ducks. This desirable result, however, is not always attained, on account of bad management and neglect.

Kinds of Poultry.—The most common poultry kept on the farm are fowls, ducks, geese, and sometimes a few turkeys. On some estates pigeons are kept, often in considerable numbers.

1. Fowls.

Breeds.—The following are the more important:—

Dorkings.—Large square body; small neck and medium head, having a rose comb; legs, white in colour, with five toes; flesh, fine and white. They are excellent table fowls, but are scarcely up to the average in laying powers. The plumage is white or coloured. The white variety is the best.

Scotch-greys.—Very like the Dorkings, and also are five-toed. Their plumage is black and white, and legs white or speckled. They are good layers, and give flesh of fair quality and white in colour.

Andalusians.—Small size, with rather long legs and neck: plumage a bluish-grey or slate colour; legs blue; cocks have large sickle-shaped tails. They give plenty of eggs, but are poor-fleshed.

Minorcas.—Small in size, but hardy; legs shorter than with other Spanish fowls, and dark-coloured; white on face; single large comb; feathers, black. Flesh is dark-coloured, and indifferent in quality, but they are very good egg-producers.

Brahmas.—Large, feather-legged, heavy birds; heads rather small; small rose comb. Their flesh is of moderate quality, and, although not above the average in egg-laying, they make good mothers. They are hardy, and rank among the general-purpose fowls.

Cochins.—Fairly large birds; wings small and incapable of flight; cocks have no long tail-feathers; variously coloured—buffs are best. They are yellow-fleshed, of not very good quality; rather poor layers.

Langshans.—Large size; long legs, slightly feathered; long, high tails; single comb; plumage, black. They are hardy, good-fleshed, but do not produce many eggs. This and the last two breeds originally came from China.

Malays.—Large, heavy breeds; close feathered; very pug-

nacious. They are brownish-fleshed, rather coarse in quality; not good layers.

Game.—Small size, often very handsome; legs clean and long; head long, with strong beak and single upright comb; breast broad; feathers hard; very pugnacious. The brown-red and old English game are the best. They have good flesh, especially the latter breed. It is, however, dark in colour. They do not lay many eggs.

Indian Game.—Large fowls, rather heavily boned; long legs and neck; plumage dark-coloured; small tail. Their flesh is of good quality, and abundant.

Hamburgs.—Small size, but well-shaped; legs long; neat head with rose-comb; tail large, and feathers of it curved. There are five varieties: Gold-spangled and Silver-spangled, Gold-pencilled and Silver-pencilled, and Black, according to their colour. The Spangled varieties are hardier than the two Pencilled kinds, and grow to larger size. The Black Hamburg is the largest of the five varieties. The Hamburgs are better layers than any other breed, but, excepting those of the Black variety, the eggs are very small. They do not often sit on their eggs, but keep on laying. They are not very good meat-producers, and do not thrive when closely confined.

Redcaps.—Derived from the Golden-spangled Hamburg, which they closely resemble. They have large, peculiar-looking combs; markings similar to Hamburgs, but not so regular; tail feathers long and sickle-shaped. They are good layers.

Leghorns.—Medium size; single-combed; long drooping tail-feathers; legs clean, yellow in colour. There are several varieties, the Brown and White being the chief. Besides these, there are Black, Buff, Duckwing, Cuckoo, and Pile. Their flesh is not of great value, but they are good layers, and their eggs are of large size.

Plymouth Rocks.—Large size and rather big-boned; comb single; broad breast and back; large tail; short, clean, yellow legs; plumage dark blue. The varieties are the Cuckoo, Black, and White. They are hardy and docile; though very frequent layers, their eggs are of good size, and they are good sitters and mothers. Their flesh is not of more than average quality.

Wyandottes.—Large size; plumage laced; legs yellow; comb rose-coloured. Very similar as regards value to Plymouth Rocks, but are rather better layers. These two breeds, with the Dominiques, come from America.

Dominiques.—Average size; rose combs; yellow legs and beaks; plumage is cuckoo-marked. They are hardy, good layers, and excellent mothers.

Houdans.—Large size; head crested; legs clean, light in colour, and with five toes; rose-combed; tail large; plumage mottled black and white. They are very hardy, plump; flesh fine and white; good summer layers; do not sit much, and require an extensive run.

Crèvecœurs.—Fine large fowls; compact, plump body; wide backs; head crested, round in female; comb forked; legs short and black; colour, metallic black. They have excellent white flesh, and readily fatten, but are not hardy. They are only average egg-producers.

La Flèche.—Large, massive birds; head has forked comb; face large, red, and bare; long black legs; plumage a metallic black. Their flesh is fine and white; they fatten easily and are better layers than other French breeds.

La Bresse.—Large breed; combs large; resemble the pencilled Hamburgs. Flesh is very good; they do not produce many eggs.

There are several other French breeds, giving good flesh of a white colour as a rule.

Bantams.—Are very small in size, and hence scarcely pay the farmer for their keep.

The Poultry-house.—On an ordinary farm the poultry-house will most probably be a fixed building. Where poultry-raising is carried out on a large scale, movable houses are the best. The permanent building should be divided into several compartments; hens and turkeys, owing to their roosting, will take up one part, and ducks and geese, which do not roost, require another. A room eight feet by six feet, and six feet high, holds about thirty fowls. All houses should be warm, dry, clean, and well ventilated. Their temperature may be raised by making them medium-sized and not too large, and, if possible, having them adjoining a stable or byre. When too cold it benumbs the fowls, does not allow them to lay on any flesh, and decreases their egg-laying powers. Dryness is essential to the well-doing of poultry. Nothing causes hens to appear more miserable than when constantly wet. A good roof of slate or tarred wood keeps out the rain, and, as a protection against damp from below, the floor should be a foot or two above the ground. The house should be often cleaned out, and whitewashed, once a year at least, with lime-wash, to which a little carbolic acid has been added. When the room is allowed to remain in a dirty condition, poultry become affected by lice. Ventilation may be secured by having a few small holes high up at the gables, or by having a ventilator fixed in the roof. The impure air rises above the other, and thus gets out by these holes. A small window should be put in the side of the room, as light adds much to the comfort of the place.

Perches are needed for fowls and turkeys. They should be three or four inches broad, with rounded edges, and from one to two feet from the floor.

An apartment may be reserved for laying fowls, but this is not necessary. Nests have to be provided, of course. They should be about fourteen inches square, and a foot high, and have their sides formed, generally, of a box. This is then partly filled in with straw, hay, or some soft vegetable material. Poultry, which are hatching eggs, should have an apartment to themselves, in order that they may not be disturbed. The nests should be placed in small compartments, secured by doors, so that the mother may be prevented from leaving the eggs at any time. A small green sod should be placed at the bottom of each nest: it prevents the eggs becoming too dry. Outside every poultry-house there should, if possible, be a small covered yard in which the fowls can take a little exercise in wet weather. Movable poultry-houses are generally raised two or three feet from the ground, and hence provide an outdoor shelter for their occupants.

An apartment for chickens and another for fattening fowls are generally needed. The chicken-coop should be placed up against a wall for protection, and should face south. It should have a large window, and a covered shed in which the young ones may run. The room should be kept warm and dry.

Fattening-rooms must be dark, warm, and dry. The darkness prevents the fowls from taking too much exercise, and their comfortable situations cause them to lay on flesh rapidly.

Movable poultry-houses are very useful on many farms. By their means poultry can be often provided with fresh runs, and such changes greatly improve their health. The sizes are similar to those of permanent houses. They run on four wheels, so placed that the floor is about two or two and a half feet above the ground. On a large poultry-farm these kinds of houses are better than permanent structures.

The Production of Eggs, and Management of Laying Poultry.

The general shape of eggs is well known, but of their minute internal structure most people are ignorant.

An average egg weighs about two ounces, although some weigh nearly three. We will now consider the different parts of an egg.

The **Shell** consists chiefly of carbonate of lime and a little phosphate of lime, and is cemented together by a small amount of

gluten, and is either white or coloured. Coloured eggs are often regarded as the richer, though not much difference exists.

The **White** of the egg consists of albumen, coagulable on heating. It is in three layers, and through it there runs a hardened spiral band of albuminous material, called the chalaza, which supports the yolk.

Between the white of the egg and the shell are two delicate membranes, one adhering closely to the shell, the other to the albumen. These two skins are joined except at the large end of the egg, where they separate and form the air-cavity.

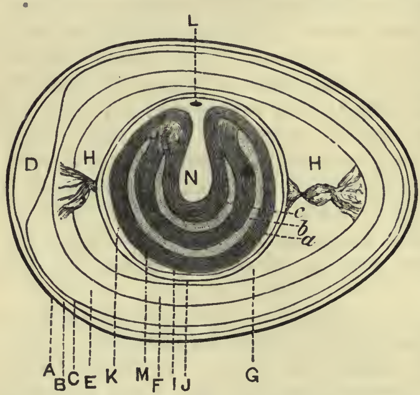


FIG. 97.—Section of an egg: A, the shell; B, membrane adhering to the shell; C, second membrane, slightly attached to B, except at the large end of egg, where they separate and form D, the air-space; E, the white or albuminous part of the egg (first layer, liquid); F, the white of the egg (second layer, semi-liquid); G, the inner white; HH, chalaza; I, inner membrane; J, very fine vitelline membrane; K, the outer part of yolk; L, the germ; M, yolk; N, utricle; *a*, *b*, *c*, separate layers composing yolk.

The **Yolk**, in the centre of the egg, is invested by the vitelline membrane. It consists of a small flask-shaped mass of white yolk, round which are arranged alternating concentric layers of yellow and white yolk, the yellow being in much the greater abundance. At the commencement of the larger mass of white yolk is seen the yellowish-white germ, or blastoderm, from which, when properly fertilized, the young chick grows. The yolk is very nourishing, containing a large percentage of albuminoids, fatty organic matters, and mineral salts. Its yellow colour is due chiefly to sulphur, which, on decomposition, is given off as sulphuretted hydrogen, causing an unpleasant smell.

Egg-laying.—The powers of various hens as egg-producers have already been noticed. The yolk is produced in the ovary, and, during its passage along the oviduct, becomes coated with albumen. The chalaza is formed by the spiral motion of the egg. It also receives its two protecting membranes and its shell, and is then expelled apex foremost. In a year a hen lays from a hundred to over two hundred, according to breed. Generally about three or four eggs are laid on successive days, and then a miss for a day takes place.

Treatment of Laying Fowls.—Poultry, in order to lay eggs, require to be well supplied with proper food, as it is only from the extra amount given that eggs are produced. Highly albuminous food is needed for the white and yolk; and plenty of mineral salts, particularly carbonate of lime, is required for the shell. When at large, the fowls generally pick up enough lime with their food, but when confined it should be supplied in a small heap near the house, in the form of slaked lime, powdered oyster, and other shells, etc. Their other food will be treated further on.

Laying poultry require plenty of exercise to keep them in good health. Soft-shelled eggs are one of the results of insufficient exercise, food of too fattening a nature and deficient in lime. When the birds are too fat, there also is often a difficulty in passing the eggs out.

It should be said that hens lay plenty of eggs when a male is not among the stock; but these eggs contain no living germ, and are of no use for hatching.

Hatching.

Before the eggs can be hatched, the germ must be alive, and this can only be accomplished by copulation. In order that this process may take place, not more than a dozen females should be allowed to every male. The cocks should be strong and vigorous, and not related in blood to the hens, as in-and-in breeding is apt to cause constitutional derangement among the offspring.

The **Hatching-house** should be roomy and comfortable, and ought to be well lighted. One essential condition is, that it should be quiet, for, if the hens are frequently driven off their nests, the eggs get chilled and the young embryo they contain dies. It is perhaps best to have each nest in a separate small compartment, about fifteen inches square and eighteen inches high, and having a door about a foot high. The nests should be made of clean soft straw, placed upon a green sod.

Sitting Hens.—Hens should be selected which may be expected to make good sitters and good mothers. Plymouth Rocks and Wyandottes make excellent hatchers. Large bulky fowls are not generally good mothers, being apt to crush the chickens, and not getting them plenty of food. Hens above three and a half years old ought not to be kept for breeding. The hen should be trained to sit, by giving it two or three old eggs the first time. If it keeps to the nest well, these eggs may be taken out after a couple of days and fertile eggs put in. The fertile eggs, when held to the light, should appear semi-transparent and of uniform density. Eleven to thirteen eggs are about as many

as a hen can comfortably cover. It is best to place the hen on the nest towards evening, when it would be coming home to roost, as then it takes better to the nest. With small stocks, April is early enough to begin sitting.

It is most advisable to place the food near the nest; where breeding poultry have to seek the food the eggs are apt to get chilled. Clean water is always required, and grain should be given in its natural state. Grit is needed; it is taken into the crop of the fowl, and acts in much the same way as teeth, grinding away the food by its movements. A dust bath is needed by the fowls to clean themselves in, and about half an hour a day may be allowed to the hen for exercise. In dry weather the eggs may be damped occasionally with warm water; a better way of damping would be to run a little warm water upon the sod at the bottom of the nest. Enough moisture would rise through the straw to give the required amount to the eggs. The hatching-room should always be well ventilated, as the chicks, when large enough, begin to breathe through the slightly porous shell of the egg; bad air would soon kill them at this stage. About the eighth day of hatching, if the egg is held up to the light, the embryo can be seen as a dark mass. When this is not the case, the egg is not fertile, and should be removed at once. When many have to be taken away in this manner it often happens that there are only enough eggs for two hens, instead of, say, three to hatch; in this case the third hen may be given fresh eggs. In twenty-one days the eggs generally hatch; those of ducks, geese, and turkeys, however, require thirty days. About a day or two before hatching, the eggs may again be tested by floating in warm water. Those that sink, contain dead chicks, and may be thrown away; the rest may be returned into the nest after about two minutes' test. It is best to allow the chickens to come out themselves, and not to break the shell. After hatching, it is advisable to leave the young with the mother for the first twenty-four hours before beginning to feed them. Then a little crumbled bread and oatmeal, or boiled rice and barley meal may be given, in a warm condition, with clean water. They should be removed from the hatching-house, and allowed to shelter in warm dry chicken-houses or coops. They should run about with the hen as much as possible. In this way they grow up to be more vigorous, and are taught to pick up various insects, worms, seeds, and other food. They should be fed frequently during the day, getting oatmeal porridge, rice, crumbled bread or potatoes, with sometimes a hard-boiled egg, cut up fine. Nothing should be given in a cold, sloppy, or sour condition. Various prepared foods for chickens are now manufactured, and are very useful. In a month or two the chickens

will be able to forage for themselves. When rather older, they become known as cockerels or pullets, according to sex.

Artificial Incubators.—These are now taking the place of sitting hens to a large extent. Their advantages are—(1) many more eggs can be hatched in a year, and at any time; (2) there are very few losses from the eggs being chilled or being broken; (3) the brooding hens can be employed in laying eggs, or may be sold. The outer case of an incubator is of wood or block tin, and is of rectangular form. At the base or side of this is a lamp (burning various kinds of oil) or a gas-burner. The eggs are laid upon a perforated curved zinc sheet, fitting into a drawer, which can be easily pulled out. Air comes in from the bottom of the machine, and, passing up through a cloth soaked in water, becomes charged with moisture, and damps the eggs. The temperature of the incubator is kept up to 104° Fahr. by the lamp, the heat from which passes along one or more pipes running through a small reservoir of water in the upper part of the machine. The water is heated, then the air above the tray, and finally the eggs. In order that the temperature may not rise too high, various kinds of regulators are used. One of the best consists of a metal capsule, containing a small amount of a liquid boiling at 104° Fahr. It is situated just above the eggs, and fixed to the water-vessel above. When the temperature rises too high the liquid boils, and communicates motion to a long needle, which, by means of a system of levers, causes a valve to open near the lamp. This allows much of the heat to pass out, and almost at once reduces the temperature to the proper degree.

The room in which the incubator is, should be well ventilated, but not draughty, and should be kept at a regular temperature, as near 60° Fahr. as possible. All eggs before putting in the incubator should be dated, and heated by placing in warm water for a short time. The latter operation is to get them at the same temperature as those already on the tray. Eggs require to be turned twice daily to get them acted on uniformly, and ought to be cooled for about five minutes each day so as to make the process as natural as possible. The water-tray below should be regularly supplied with water, warmed a little. When the chickens come out of their shells they should be removed to a warm room, and the remains of their eggs taken away.

Artificial Mothers.—These are very useful where large numbers of chickens are produced by the incubator. They each consist of an apartment, heated by means of a well-protected lamp. The structure is well-ventilated, warm, dry, and has certain means for keeping the temperature regular. Connected with this nursery part is a partly covered run. The nursery is so arranged that

the chickens do not crowd each other, and can be easily and regularly fed. The "artificial mothers" are often upon wheels, and can thus be easily removed from one place to another.

Foods.

In feeding it should always be remembered to give the food often, and quite fresh. The food for chickens has already been mentioned. They must have soft food, and no whole grain until five or six weeks old, although a little crushed buckwheat may be given occasionally before this time. The young poultry should be allowed to run about in some field if possible. There they pick up various worms and insects, and also a few nice fresh leaves. If breeding poultry are needed, plenty of mineral salts, etc., should be given in the food in order to get strong frames. Should the young fowl be intended for the table at an early age, soft foods are given to get flesh with little bone.

Food of Ordinary Fowls.—Laying and hatching hens require foods rich in all the constituents. Grain is very useful; oats, buckwheat, wheat, and barley are the best kinds. A mixture of two parts of barley meal and one part each of oatmeal and Indian meal has been recommended, made into a warm crumbly mass with boiling water. Two meals a day are sufficient in summer, but three are required in winter. The first, given about dawn, should be of soft food with a little animal fat in it. The second, at noon, consists of chopped green food, with mashed potatoes, table scraps, and either oatmeal or the whole grain. About five o'clock, p.m., a feed of grain, oats, wheat, barley, buckwheat, or maize, should be given. Maize is a good winter food, containing a large percentage of heat-producing elements. Boiled rice, mixed with oatmeal, answers well in summer. When feeding, never give food in large quantities at a time, and never throw grain among a large number of fowls; the stronger will prevent the weaker from feeding. Clean water is always needed, and should be often supplied.

Fattening Fowls.—In order that as much profit as possible may result, it is best to keep each fattening fowl in a separate dark compartment, where they will not run about and thus use up their store materials for energy. Again, the room should be warm and dry, and the poultry as comfortable as possible. Rice, prepared as stated before, and maize are the two most valuable grains for fattening. Soft food should be given, and it is well to mix it with skim milk, as this is said to whiten the flesh. Barley meal and oat meal, made into a paste with milk, are good foods. Another mixture, prepared similarly, consists of two parts of

barley meal, and one each of maize meal and buckwheat. A little cattle spice is very good for giving a flavour to the food.

In order to get more food into the fowl, cramming is sometimes resorted to. The process is either performed by hand or by machine. In the former case, the food is made into a paste, and then formed into pellets, an inch and a half long and three-quarters of an inch broad. It is then dipped into milk, and inserted into the fowl's mouth, which the operator has been keeping open. It is then pressed by the fingers gently into the crop, until filled. Cramming machines are sometimes used. They consist of a vessel holding the food, which should be in an almost liquid state. Attached to this vessel is a small force-pump, worked by the foot of the operator by means of a treadle. From the pump there comes an india-rubber tube with a nozzle. In operating, a few inches of the tube are gently forced down the throat of the bird, which is held in both hands. By pressing on the treadle, food is forced along the tube into the fowl. When the crop is filled, the tube is gently pulled out, and the fowl set at liberty.

2. Ducks.

Breeds.—There are only three important breeds of ducks.

Aylesbury.—Large body; plumage white; legs short; bill long, flesh-coloured; feet flesh-coloured. It is a very good layer, and also gives plenty of fine flesh.

Pekin.—Plumage white; bills and feet orange yellow; legs placed far back. Very good layers, and their cross with the Aylesbury grows to large size and makes a good table bird.

Rouen.—Large size; colour like that of wild duck, from which they are thought to be descended. They are good layers, hardy, and have good flesh. They do not fatten rapidly, however, and must not be confined.

Hatching.

The eggs may be put under a hen, as the duck does not make such a good sitter and mother. The incubator is very useful, and ought to be used wherever enough eggs have to be hatched. It should be remembered always to have the eggs damp; on no account should they be allowed to get dry.

General Management.—The duck house should always be well littered, and, as the ducks roost on the ground, no perches are needed. The young ducklings, if for the table, should be

kept away from ponds and streams; otherwise they require access to water. Barley meal, and afterwards Indian meal and bran, made very watery, are good foods for the young ducks. Boiled potatoes are useful as a change, and green food may be given in small quantities. Hard-boiled eggs, chopped up fine, and mixed with breadcrumbs and boiled rice, make the best food for the ducklings when first hatched. After they are about five weeks old, they may get coarse rice and chandlers' greaves, boiled together. Plenty of grit is needed. The ducks will be ready for the market in about eight weeks.

For the ordinary ducks, intended for laying purposes, fattening food should not be given. Barley meal, and pollards, with a little oat meal, make good food when a little hot water is added. Chandler's greaves are very useful when mixed with other food. Twice a day is sufficient for the ducks to be fed. Always remember to let them have plenty of pure water, or else have the food in a sloppy condition, as ducks find great difficulty in swallowing dry food.

When spring ducklings are needed, the birds may be mated about December, three or four ducks being sufficient for each drake. Ducks often have a bad habit of laying their eggs away from home; to prevent this, they should not be let out until about ten o'clock in the morning, and should be encouraged, by feeding, not to wander away.

3. Geese.

Breeds.—Only two pure breeds of geese are known.

Toulouse.—Large, square-built bird; plumage grey; bill and feet, deep orange; head and bill strong; throat has a "dewlap." It does not mature early, and hence is of little use "green." It makes, however, very large weights, and its flesh is of good quality. They are very good layers, but very rarely hatch.

Embden.—Plumage white; bill flesh-coloured; legs and feet, orange; stands more erect than the Toulouse. It matures rapidly, but does not make quite such large weights as the former breed. It will hatch its eggs, but as a rule only produces one brood per year.

The common breed of geese are often a cross between Toulouse and Embden. They are smaller in size, but more prolific, rearing two or three broods a year.

Hatching.

The eggs may either be hatched by giving about four each to a few Brahmas, or by the goose, if not a Toulouse. Twelve

to fifteen are about the number for one goose to hatch, and when the female has got about this number, she often commences to sit. If the nests are in a house, they should be often sprinkled with luke-warm water.

General Management.—The goslings, on coming out of their shells, should be left alone for about a day. They may then be taken into a sunny field with the goose. For the first week or so, if at all wet, they should be confined to a large roomy coop, well protected from both the sun's rays and the wind, and having no floor. They should be well supplied with fresh green turfs, as they are very fond of the young leaves of grasses. Oatmeal paste, made into pellets, may be given, with plenty of good water in a large shallow vessel. Scalded wheat mixed with the meal is a good food, with boiled potatoes and other vegetables. After they are about ten days old they may be allowed to forage for themselves, and if to be sold at Christmas, or kept for breeding, they are run on the pastures all summer, and receive little or no extra food. After harvest they are put on the stubbles. They should be brought home before dusk, and then may get a feed of grain. In the morning the fattening goslings should receive a feed of oat meal or barley meal made into a paste. If intended for breeding, they should be allowed a few turnips frequently, or some vegetables or household scraps, with their corn. They require large runs, and a good pond to swim about in. Owing to their great powers of foraging for themselves, they do not cost much for their keep, and hence, when large runs are easily obtained, they are among the most profitable of the farmer's poultry stock.

Fattening.—The young goslings, when not for laying purposes, should be fattened from their birth, if to be sold "green" at Michaelmas. One essential condition is, that they are not separated one from another, but all fattened in one flock. Their food is similar to that mentioned before; barley meal, light wheat, maize, and brewers' grains being also given. Most geese are intended to fatten by Christmas, and are nearly always killed before sending to market. They ought to fast for about twenty-four hours before their death. Their feathers, especially those of the Embden goose, are of considerable value.

4. Turkeys.

Breeds.—There are three principal breeds, the Cambridge, the Black Norfolk, and the American Bronze. The original turkeys were imported from America, where they are still found wild.

Cambridge.—Large size; full, broad chest; broad tail; stands upright. It is a fairly good table bird.

Black Norfolk.—Plumage black; not quite so large as the last, but its flesh is of finer flavour.

American Bronze.—The largest and handsomest variety, making heavy weights, and hence of more value per pound than the ordinary kind.

General Management.—If one thing more than any other must be insisted on in turkey-rearing, it is that they be kept warm and dry. This is due to their being natives of a more southern climate than England. Clay soils, especially when not drained, prevent success, and on these places turkeys should never be kept. On the lighter and drier soils of Norfolk they can be bred with profit. In-and-in breeding tells strongly on the constitutions of the turkeys, and hence it is advisable to frequently change the stock.

The hen begins to lay her eggs about March, and, when observed seeking a nest, she should be confined in a place in which it is desired that the eggs be laid. After laying the first egg she will always keep to the same nest. If this is not done, the eggs are often lost through being laid in out-of-the-way places. Remove the eggs, and keep them packed in bran until enough have been collected for a hatching. Then the eggs are returned to the nest when she shows a desire to hatch by remaining on the nest for a considerable time. During hatching the turkey should be disturbed as little as possible, and consequently she should have plenty of food handy all the time. Leave the young birds alone for some time after they are hatched. Then remove them with the parent to a large dry coop, and give them hard-boiled eggs, chopped up fine with a few fresh green leaves and onions (which are very important). Boiled rice and soft food should also be given. Animal food should be given, in a fine state of division, in small amounts, until the young ones are fairly well grown. The old hen should not be allowed to take them into the fields, as she is apt to take them long tiring journeys.

When fattening, they ought to be shut up in dark rooms, and there given two meals a day of barley meal and milk, with a few slices of turnips, or mangels, or any nutritious green food. Corn, meal porridge and milk are very good, and some sort of grain, oats, wheat, or Indian corn, should be given.

Turkeys as Mothers.—Turkeys are, as a rule, very attentive to their young, and have been recommended for hatching hens' eggs. For the latter purpose they would scarcely surpass the ordinary hen, although they would be able to take more under their care. A peculiarity of the turkey is, that one copulation at

the beginning of the season renders fertile all the eggs in the ovarium.

5. Pigeons.

Pigeons are of little trouble, and, being generally easily sold, it may be wondered that a few are not kept on every farm. There are many breeds, but for table and profit the Blue Rocks are the best. The dovecots should be very clean; the pigeons will make their own nests, if allowed. When placed in a warm situation, they will lay from February to December. They only hatch two eggs at a time, but may have ten hatches a year. After the brooding season is over, the nests should be cleared out, as a considerable amount of dung accumulates in them. The dung is rich in fertilizing matters. Pigeons should not be given too much food, as they gather nearly enough themselves. Grain is one of their best foods.

6. Guinea-hens.

These are handsome birds, not commonly met with on farms. The spotted variety is hardier than the white, and, if any are to be kept, it should be these. The eggs are hatched by a common hen or an incubator; the period of incubation being one month. The young ones are then reared in a coop, round which is a guard to prevent them from straying. It should be moved on to fresh ground every other day. They are fed similarly to young turkeys. They forage well, and give good flesh. Their eggs are small but well flavoured. The disadvantage is that they are very quarrelsome and noisy, and on this account are often banished from the farmyard.

Marketing of Poultry and Eggs.

Killing and Dressing Poultry.—As a rule, the necks are first dislocated by extending the fowl and then bending the head suddenly backwards. In order to pull them more easily, the feathers are often pulled as soon as this operation is done. They may then be hung up by the legs; the blood collects in the neck, and does not colour the flesh. Turkeys generally get their throats cut in order to bleed them well; they are then plucked, the feathers being only left on the neck and rump. Geese should be well fasted before killing, and should be allowed to clean themselves well in the pond, getting clean straw to lie on in their houses. Mr. Edward Brown gives the following account of the French method of dressing and shaping poultry. There are two

principal systems, one for the La Bresse fowls, the other for any kind. In the former the hens are plucked as soon as killed, and, whilst warm, they are wrapped in two cloths of fine and coarse linen respectively. These are tied on tightly, the outer one being stitched up and damped. The birds remain in these for thirty-six hours, and when taken out are long in shape, with pointed ends, and perfectly round, the legs and wings being pressed tightly into the sides. In the other system, when plucked, the head, legs, and lower bowels are removed. The fowl is then laid back downwards, on the dressing-board, and the breast pressed in with the hands, causing the ribs to crack slightly and loosen. All the air is thus forced out of the bird. It is then turned back upwards; the hocks having been already tied with the wings through them, and the rump supported by a block of wood and the neck by a pad, a wet cloth is drawn very tightly over the back, and the tapes attached to it for the purpose, tied down to nails on the sides of the shaping boards. The whole is well drenched with cold water, and left to set. On receiving the fowl, the cook bends the legs into their former position, and thus raises the meat on the breast-bone.

If the poultry are not to be sent at once to the market, they may be kept in a very cool room, after having had their intestines removed. When sent by rail, they should be packed tightly in damped hampers.

Eggs.—It is best to sell all eggs as fresh as possible, but sometimes they have to be stored before sale. When to be kept any length of time, prepare the following mixture in a large tub:—water 15 gallons, common salt 1 lb., cream of tartar $\frac{1}{4}$ lb., well stirred. The eggs are packed tightly, apex downwards, in another vessel, and enough of the mixture poured in to cover them. This goes on until the case is nearly full. On standing a few days, a crust forms on the surface and excludes all air. When eggs are being collected for setting fowls, they should be placed, point down, in layers of bran.

Infertile eggs will keep longer than those containing germs; as the living organism will soon die, decomposition will set in, and an unpleasant smell be produced.

Eggs should be carefully packed on sending to markets. Various kinds of egg-boxes may now be cheaply purchased. The eggs are either placed in holes in trays, or may be placed in an even manner between layers of clean fresh straw.

Feathers are of minor importance, and only a small weight is obtained from each fowl. Those of the Embden goose are about the most valuable. If the fowls are killed on the farm, of course the feathers, excepting the large strong ones, should

be kept. They should be heated and dried several times. If tainted, they require to be steamed. Feathers have been used as manure, as they contain a small percentage of nitrogen, but this use is very limited.

F.—*Bee Management.*

Classes of Bees.

Bees may be divided into three classes, (1) the Queen bees, (2) the Drones, and (3) the Workers.

The **Queen Bee** is longer, tapers more at the extremity, and has a back of a darker and glossier hue than the ordinary bee. Her wings are small proportionately, and her sting is curved instead of being straight. She is not provided with any means of extracting the honey of flowers, her only function being to produce eggs. As a rule the queen bee lives longer than her subjects, being known to live for five or six years. When old, and unfit for breeding, she is generally killed by the bees, and one of the princesses takes her place.

The **Drones** are the male bees. They are somewhat cylindrical in form, not so long as the queen bee, but larger than the workers. Their colour is a deep brown, and they are very hairy. Their wings are large and strong, and their eyes very powerful. Drones are not capable of taking the nectar of flowers, and hence have to depend upon the food stored up by the other bees. They are produced in considerable numbers every year, and have as their function the fertilization of the queen, an act which only requires to be done once in her life. They have been said to be of use, in the summer, in producing heat in the hive in the absence of the honey-gathering workers. In the autumn, when all the bees return to the hive, the drones are considered useless, and are accordingly pushed out of the hives, and soon die.

The **Workers**, sometimes called Neuters, are females with undeveloped reproductive organs. They are much smaller than the two former varieties, and very rarely engage in reproduction. In a few cases a worker has been noticed to lay eggs, but these are extremely rare exceptions to the general rule. As seen from their name, this is the working class of bees. Their functions are extremely varied, but among them may be mentioned the gathering of pollen and honey, building of comb, nursing young bees, ventilating the hive. These will be referred to more fully later on.

Life of the Bee.

The eggs are produced by the queen bee. If starting for the first season, when a few days old, the queen leaves the hive on what is called her "wedding flight." It is her endeavour to meet a male or drone, and thus get fertilized. This fertilization can only take place on the wing, and it is because of the chances of missing each other, that such a large number of drones are produced. On meeting, fertilization takes place, and the queen returns to the hive with the male organs of generation attached to her abdomen. The male generative fluid is stored up in a small round case, called the "spermatheca," situated near the Y-shaped ovary, and opening into the lower part of it. A few days after this act takes place, the queen commences laying eggs. She deposits one in each cell (which are of hexagonal shape) by inserting her abdomen into the cell, then a slight muscular movement forces the egg out of her ovary. She then withdraws herself, and the egg, rarely more than one, will be found attached to the walls. The queen is very rapid in performing this act, a thousand to two thousand being generally laid in a day. The time of greatest activity is from April to May; through the rest of the year they are laid in less abundance,—except in the three winter months, when reproduction ceases. The eggs are of a pearly colour, about one-fourteenth of an inch long and one-seventieth broad. If intended for workers, they each receive a drop of the male genital fluid when passing out of the ovary; when for drones, this does not take place.

The eggs are taken charge of by the nurses, which keep them warm by the heat of their bodies. In three days the grub is developed. It is extremely small, incapable of motion or sight, and with a very rudimentary mouth. As they are not able to feed themselves, the nurses prepare a food in their own bodies, composed of water, pollen, and honey. This they pour over the larva until it floats in it. One side of the body is always kept dry, in order that it may absorb air through the breathing-pores placed along its side. Their food is very nourishing, and causes them to grow rapidly. The pollen is the chief tissue-former, and is rich in phosphates; the honey produces the energy required for its various movements. When it fills about two-thirds of its cell, it begins to spin a cocoon round itself, while the nurses close up the entrance to the cell with a cover, composed of wax shreds and pollen grains cemented together by a sticky substance called "propolis." These covers are of convex form, and darker than the rest of the comb; hence it is easy to distinguish between the brood cells and those containing honey.

Soon after changing to the pupa state, many important alterations take place. The segments of the body form into three parts, the head, thorax, and abdomen. The nervous system is altered from chains of ganglia into masses situated in the head and at the insertion of the wings and legs. Antennæ and eyes form on the head, and the mouth becomes more fully developed. Wings and legs are formed, and may be seen closely folded against the body. The outer covering also hardens, and becomes of a dark grey colour. When these changes are complete, the perfect insect comes out of the cell. The queen bee occupies sixteen days in passing from the egg to the perfect state, the workers nineteen to twenty-two days, and drones twenty-four days. The bee then has all the remains of the cocoon taken off it, and takes as its first work the nursing of some of the young ones. After a few days it begins to try its wings, and soon is engaged in getting honey.

Every year several princesses or young queens are formed, for two reasons : (1) to take the place of the queen if she dies, (2) to act as queens to new broods if the inhabitants of the hive become too many. The eggs from which they come are laid in an ordinary worker's cell, from which they are removed to the royal cells by the nurses. The royal cells are pear-shaped, and are much larger than the ordinary kind, thus allowing the abdomen to be fully developed. The young grubs are fed with what is known as "royal jelly," consisting of a mixture of honey and partly digested pollen, and very stimulating in character. The princesses come out of their cells in a shorter time than their subjects. If allowed to have her own way, the old queen will now destroy her rivals, from a desire to reign supreme. Should there be any necessity for swarming, she is restrained from doing this by the other bees, otherwise she kills them all. The same spirit of enmity is displayed by the princesses, the first one developed generally tearing open the cells of the others and killing them. Only on occasions like these do the queens use their stings.

Functions of Bees.

The functions of bees are numerous, and, as the workers are not divided into special classes, one bee learns to do its part of all the necessary work. Of course this does not apply to the queen and drones, who are solely engaged in reproduction. For convenience we may divide their work into (1) indoor and (2) outdoor.

Indoor Work includes nursing, ventilating, comb-building,

cleaning, etc. We have already referred to nursing under the heading of "Life of the Bee." Ventilating is carried on greatly in summer. The operation requires two sets of workers, one just without and the other just within the hive. The former, by fanning with their wings, force fresh air into the hive; the latter, by a similar mode of procedure, get rid of the foul air. It should be said that there are no soldiers set to watch the hive, and those which fly out on disturbance are probably ventilators.

Comb-building.—The wax of which the combs are formed, is derived chiefly from honey, though a little pollen is also needed. The former is a carbohydrate, but the latter is albuminous, and hence is needed for the repair of tissues. When the combs have to be built, great numbers of the workers gorge themselves with honey and pollen, and then hang in festoons from the roof of the hive. There they remain for a considerable time in an apparent state of inactivity. The nourishing matters they have taken are digested, and absorbed into the blood, and taken to all parts of the body. These matters are then used up by the protoplasm of the cells of those organs which require them, and made into fresh protoplasm varying with the proportion of matters supplied by the food. The bees form the wax by the metabolism of this protoplasm, during which operation unusual heat is produced. The material is then exuded from sacklets on the under surface of each of the four intermediate ventral segments of the abdomen. There are two sacklets to each of these segments; they are trapeziform in shape, and mould the plates they exude into this form. On being exposed to the air, the wax, which has hitherto been almost liquid, thickens considerably. It then is withdrawn by the hind feet of the bee, and carried by the fore feet to the mouth. There it is worked up with a little saliva and softened ready for use. The bees then deposit their wax, after thorough mixing with saliva, against the top of the hive, making first little perpendicular lines. They are then succeeded by other bees, which mould the wax into the proper shape of the cell. More wax is supplied and used up until the cells are finished. They are in the shape of hexagonal prisms with pyramidal ends. The cells slope downwards slightly from the mouth, and thus are better able to hold honey, etc. They are white at first, but soon turn to a darker hue. The size of the cells varies somewhat, but on an average the ends of nineteen drone cells or twenty-seven worker cells occupy a square inch.

The formation of wax is voluntary, and controlled by the bees' nervous system. Bees are said to consume twenty pounds of honey and pollen in order to make one pound of comb, and from this we see the benefit of supplying artificial or old comb. Not only

is the honey saved of which the bees would have formed the wax, but the time occupied in building would be more profitably spent in getting honey. The combs taken out of the hive should always be kept, disinfected after removing the honey, and returned to the hive at the proper time.

Substances gathered by the Bee, and their Uses.

The outdoor work of the bees consists in gathering up certain materials for the use of the community to which it belongs. Chief among these is honey, which we will now consider.

Honey.—This is a carbohydrate composed chiefly of two sugars, one closely allied to grape sugar (glucose), and crystallizable on coming in contact with the air; the other will not crystallize, and generally contains small quantities of mucilage and colouring matter. It is derived mainly from the nectar of flowers; lesser amounts are, however, obtained from the juices of ripe fruits and from what is called "honey dew." There are two kinds of "honey dew," the one being a viscous exudation from the leaves of particular trees, such as the oak; and the other a secretion of several aphides. The second kind, though capable of being employed as food by the bees, almost spoils the honey for human use. The white Dutch clover and the heath blossoms give the best honey. The bees may sometimes gather poisonous substances with the honey, which, though harmless to the insects, are injurious to human beings. The honey collected in early summer is the best, and that got late in autumn the poorest.

Bees take the nectar from its receptacle, generally situated at the bottom of the flower, by means of their long flexible tongues. With these they suck up the nectar into the first stomach, which is an expansion of the gullet. According to some authorities it undergoes a slight chemical change, and part of it is sometimes taken into the true stomach, where it is absorbed as food. The main part, however, is carried to the hive, and regurgitated into one of the cells of the comb. When any of the cells are full, they are covered over by a coat of propolis. A portion of the water the honey contains is soon evaporated, and the solidifying which takes place is known as ripening.

Pollen.—This is derived from the pollen dust of flowers. When gathering honey, they get well dusted with the pollen grains, produced by the anther lobes of the stamens (the male part of the flower). Some of this they deposit on other flowers, causing fertilization, referred to later on. On taking flight, they rapidly clear themselves of the pollen dust by rapid combings of their wings. They then roll it up into small pellets, which they

deposit in the pockets on their hind legs. In the hive, the pollen is kneaded up into a paste, and then stored away in the worker cells. In order to preserve it from fermentation, a layer of honey is spread over the pollen, and the entrance to the cell is then covered over. The greatest amount of pollen is collected in April and May, when the plants begin to blossom.

Pollen is very useful as food for the bees, as it is the chief tissue-forming substance; the larvæ are fed chiefly upon it. The queen bee requires plenty of this substance, owing to the rapid waste of her tissues, caused by her functions. In winter, when this substance is not obtained from outside sources, a substitute should be supplied in the form of pea meal or rye meal.

Propolis.—This substance, which has not yet been of any use except to the bees, is derived from certain trees, such as the alder, birch, chestnut, fir, and willow, or nearly any resinous tree. It is chiefly got from the leaf-buds, and is carried to the hive in a similar manner to pollen. It is mixed thoroughly with a certain proportion of wax, and then, if not to be used immediately, it is stored up in outer pentagonal cells. It is used for stopping up chinks, cementing bodies together, fastening the comb to the walls of the hive, and also for covering any obnoxious body which may have got into their place of abode.

Relation of Bees to Flowering Plants and the Production of Fruit.

Bees and other insects are the means by which most plants get fertilized. Grasses and the gymnosperms have their pollen carried from one to another by the wind, and hence are called anemophilous. The others are entomophilous. When the bee visits the flower for the honey, it gets well dusted with pollen. This it carries to other flowers, and, in the attempt of the insect to get the nectar, some of the pollen becomes attached to the stigma, and fertilizes the ovule. By this means only is the perfect seed produced. The act of fertilization seems to stimulate the surrounding tissues to renewed activity and growth. The walls of the ovary and other parts become succulent, and store up sugar and vegetable acids. When a flower contains more stigmas than one, as, say, the apple, which has five, they must all be fertilized to produce the perfect fruit. Should an apple be fertilized in less than five segments, the fruit appears withered and imperfectly developed, and it will also be more liable to be blown off by the wind. It can easily be seen that it will pay any fruit-grower to have a few hives of bees in his orchard.

Hives.—There is no necessity to go into descriptions of the

various kinds of hives. They should afford warmth and protection from all weathers to the bees. As a rule, the simpler hives are much better than the elaborate arrangements. They should all be on the bar system. The hive is in two parts, in the lower one of which breeding is carried on, and where the bees pass the winter. In the upper part supers are placed; these are small oblong cases without back or front. They fit closely against one another, and are taken out as soon as filled, being then ready for sale. The bees build their comb in these, beginning at the top. When honey is to be extracted, bars are used on the top in the place of the supers.

Natural and Artificial Swarming.

Swarming takes place when the number of bees in the hive are so numerous as to interfere with the work. A considerable number in consequence issue forth, with a queen at their head, in search of a new home. This generally takes place in May or June. It is always the old queen which sets out with the swarm; this being on account of her desire to find a home where she may reign supreme, when not allowed to kill the princesses. Before starting, the bees, which are the older ones, load themselves with honey, so as to be prepared in case any want of food may be experienced. They usually swarm between 10 a.m. and 1 p.m., on a fine morning. The distance which the bees travel varies greatly, but on the lighting of the queen, which usually takes place on the bough of a tree, they all cluster around, forming a dense living mass. The operator now covers his head and neck with a large loose veil, generally worn attached to the brim of a straw hat. His hands are also protected by a pair of thick gloves. He takes a dome-shaped straw skep in his hand, and gently shakes the swarm off the bough into it. They usually drop in a mass into the skep, and do not fly about much. The bees are then taken to an empty hive, and put in. If the hive is a straw one, it is inverted and the floor-board taken off. The bees are then rapidly jerked into it, the floor-board replaced, and the hive put into position. It is well to have one side slightly raised for some time, so as to allow any stray bees to rapidly enter. When the bees are to be placed in a bar-framed hive, the top of it is removed, and sheets of guide-comb placed in the frames. The insects are collected as before, and shaken into the hive, the top of which is then replaced.

It sometimes happens, when two or three princesses are left in the hive, that a second or after swarm takes place. As a rule, the stock left after the first swarm, are strong and numerous, when this happens. Should there be only a weak stock, the young queen is

allowed to kill her royal sisters. The after flights may take place later in the day than the first one, and are usually less numerous. Unless very strong, it is not advisable to allow them to make a separate colony. In some cases there are two or three after flights, but these generally weaken the parent stock greatly.

Should there be two separate swarms near the same time, they should be amalgamated. They are both collected by the skep, and one put into the hive while the other is emptied out on a table. The hive is then placed a little above those on the table. The bees soon ascend into the hive, and the two swarms are thus united. The two queens, for there is a queen to every swarm, will, however, fight for the supremacy until one is killed.

The process just described may be called natural swarming.

Artificial Swarming.—This is much better than the last, being done more expeditiously and at a time suitable to the owner. Instead of much time being wasted by the bees flying about in search of a fresh home, they are put into their new quarters quickly, and their work of gathering honey, which is usually plentiful at the time, is not stopped. Swarming should take place a few days before it would occur naturally. Of course, swarms should only be taken from strong stocks. The chief methods of artificial swarming are by driving, which may be "open" or "close."

Close Driving.—In this method a few puffs of tobacco smoke are first blown into the hive. This causes the bees to rush to the combs and gorge themselves, after which they are much more tractable. The operator, who has on his veil and gloves, now takes the hive off its foot-board, and inverts it in a pail partly full of water, to steady it. Another empty hive, of nearly equal diameter, is placed upon the first, and around the junction of their rims a cloth is tied, so as to prevent any bees from flying away. The lower hive is then drummed continuously with a stick or the hands, thus causing the bees to ascend into the upper. The queen, with about three-quarters of her subjects, take up their abode in the new hive, which is placed in the old position, and thus is reinforced by the workers returning from the fields. The old hive, containing the comb, eggs, larva, young bees, and a few old ones, is placed at a short distance from the other. One of the infant princesses is quickly matured, and thus the stock receives a head, while it is rapidly strengthened by the workers developed from the larva.

Open Driving is very similar to the last, except that the hive into which they ascend is placed over the other at an angle, and only resting on it for three or four inches. It is supported in this position by skewers and iron wires, thrust through both hives

where they meet, while others prop it up in front. This leaves the hands of the operator free, and, there being no cloth around, he is able to observe the passage of the queen, and also to tell when enough insects have passed into the hive to form a fairly strong colony. Of the two systems, the open is the better, for reasons before stated.

The above remarks apply chiefly to bees in straw skeps.

The following precautions should be observed in artificial swarming:—

(1) Drones should be fairly numerous when swarming is attempted, unless a fertile queen is to be given to the new colony. If this is not the case, the new queen may run the chance of not getting fertilized.

(2) Honey should be abundant at the time, or the bee-keeper will have to feed the swarm for some time.

(3) Swarms should be taken only from strong stocks.

(4) A swarm without a fertile queen must be supplied with ready-formed comb, or it will only produce drone-comb itself.

(5) When swarming, it is well to place an empty hive, into which a little syrup has been sprinkled, near the old stand during the operation. This will divert the attention of workers returning from the fields for a time, and prevent them from attacking the the operator. They may afterwards be allowed to go into the hive, among their old companions.

General Management of Bees.

Winter.—It is in winter that the bees will require most attention. As soon as cold weather is about to commence, the hives should be well protected by some covering. Owing to the pollen and honey, which are the natural food of the bees in winter, being removed in autumn, it is necessary to give some substitute. This is usually given in autumn. Syrup is a common food, either in its ordinary form, or made by boiling about 5 lbs. of sugar with with 2½ pints of water, and adding a little vinegar, salicylic solution, and a few grains of salt; a little pea meal may be added, to take the place of pollen. The vinegar prevents the syrup from crystallizing, while the salicylic acid is an antidote to the disease "foul breed," and also helps to preserve the syrup. The syrup is put into a feeder, which is placed near the top of the hive. The feeders are of different kinds; one of the simplest consists of a glass jar placed, mouth downwards, on a block of wood, which has a hole cut in it to receive its neck. Over the mouth of the bottle is placed a piece of fine muslin, fastened round the neck after the syrup has been put in. Over the hole is a piece of

perforated zinc with very fine meshes. The bees can readily suck up the syrup they want, while, if the bottle is only small, there will not be much fear of the syrup flowing out of the feeder. The box feeder is the best for bar-framed hives. The following is a description of a simple form. The bottom extends from one end to within about one inch of the other; here an upright partition is placed, being slightly lower than the two ends. The bees enter the feeder at the bottom, between the partition and the end, and crawl over the partition into the compartment containing the syrup. A perforated stage should float on the syrup. The feeder should be fitted with a sliding glass top, and is placed on the top of the bars. A hole is cut in the covering to allow the bees to pass from the bars to the feeder.

Instead of syrup, what is called "sugar-cake" may be used. It is made by adding a pint of water, in which is a little vinegar, to six pounds of loaf sugar, and then heating it over a steady red fire. A scum forms, which should be removed. When all the water is evolved, the mixture is allowed to cool in shallow dishes. It is afterwards placed, in small amounts at a time, on the top of the frames.

During the middle of winter little albuminous food is needed, that used in heat-giving only being required. Towards spring, however, the queen begins to lay her eggs, and the nurses are actively engaged in preparing food for her and for the grubs. Albuminoids are needed for this, and in a state of nature would be supplied by the pollen. As this substance has to be taken away with the comb, some substitute is usually given. The best is pea meal; rye meal or wheat flour may be used instead, but are not so valuable. It is not advisable to leave any pollen in the hive in autumn, as it is apt to mould. A mixture of pea meal and syrup should be made, well stirred up, and of such a consistency as to admit of being held upon a knife. It is then pressed with the blade into the cells of some of the extracted comb, which is then put back into the hive. The bees soon begin to feed upon the mixture, which is very nutritious.

Spring.—Feeding may be continued well into the spring, and plenty of the artificial pollen should be given, as it stimulates the bees to greater activity. The floor-boards of the hives should be removed, and fresh ones put in, or the old ones should be thoroughly cleaned and replaced. All mouldy or injured comb should be removed, and towards the end fresh comb may be put in, if there is not sufficient. If stocks have to be transferred from one hive to another, it is often done. Swarming may take place from strong hives as early as April. The process has been described previously.

Summer.—During the season, the bees quickly increase their

food stores, and breeding also goes on rapidly. The hives should be placed in such a position that they may not have to go long distances for the honey, and thus waste valuable time. It is on this account that hives are often taken to heather-clad moors. Secondary swarming should be prevented, if likely to take place. It should be seen that the hive is well supplied with comb. If it has not got much, artificial comb may be added, but the bees should not be allowed to manufacture their own.

Autumn.—In autumn, part or whole of the honey is generally removed. In a bar-frame hive the small boxes are usually removed as they get full. Often, however, the whole of the honey is in large combs, and cannot be removed in such an easy manner. In order to make the bees more tractable, they generally get a little smoke puffed in by means of a fumigator (a small pair of bellows burning rags, fungi, brown paper, etc.). If the hive be a straw skep, it is inverted, and rested in a pail, and then as much comb is taken out as needed. The comb near the outside of the hive contains purer honey than the rest. The honey is either sold in the comb, or extracted. The latter operation should be performed as soon as possible after the comb is removed from the hive, as the honey rapidly thickens. The comb may be sliced with a sharp knife, and then strained through muslin into a jar. For quicker despatch, an extractor is used. This consists of a small cylinder, into which fits a rectangular frame with two upright wire cages, each holding a large piece of comb. The frame is turned round rapidly by a handle at the top, and the centrifugal force causes the honey to fly out against the walls of the cylinder, down which it trickles. From the bottom, which is of conical form, it runs away through a tap into any suitable vessel. The amount of honey varies greatly, but as much as forty-five pounds may be taken from a strong hive. Honey is subject to a vinous fermentation, and this is taken advantage of in the preparation of mead.

In autumn, the bees receive small amounts of the food on which they have to live through winter. It is made somewhat liquid in character. The hives are also well clothed when cold weather commences. It is often advisable to unite two stocks, if not very strong ones, as the heat of the hive is better kept up by a large, than by a small, number of bees. Before the union, both hives should be smoked. One lot is then emptied out on a table, and sprinkled with sugared ale. The other smoked hive is inverted, and the inhabitants slightly sprinkled with the ale. The foot-board is removed, and the bees swept into the hive, after which it is returned to its original position. It is best to remove one of the queens, if both hives are possessed of one, and thus prevent a royal battle.

CHAPTER VIII.

DAIRYING.

The Dairy.

Cleanliness.—Strict cleanliness in the dairy and *everything appertaining to it* is essentially necessary for success in butter-making. Regulation of temperature is also of vital importance.

The **Dairy** should usually consist of two rooms, one of which should be used for no other purpose than the storing of butter or milk; with a smaller one for washing up, hot-water boiler, and stove.

Situation.—Upon a gravelly subsoil if possible, with a northern aspect, and, if unattached to the farmhouse, the southern and western sides should be protected from the sun. Air should circulate freely around it, and all source of smell must be removed from its vicinity, viz. piggeries, cow-byres, stables, etc. *No cesspool should be near the dairy*, for milk takes in all odours, as well as the germs of every ferment that is blown across its surface. To save time and labour, it should be conveniently situated for water-supply and receiving the milk.

Construction.—The walls should be hollow, with an air-space between them, to guard against variation of temperature; best bricks, well pointed, those facing inward being glazed, plastered, tiled, or cemented, with a polished surface, so that they can be easily cleaned. Roof of best tiles, or perforated Staffordshire tiles. A thatched roof gives the most uniform temperature, summer and winter.

Ceiling.—Of tiles, plaster, or polished cement, with air-space between it and roof. There should be a ventilator in the centre.

Floors.—A slightly inclined plane of concrete, Victoria stone, glazed tiles, or flags, well laid, and carefully cemented in the joints.

Drains.—Open gutters, to carry the water *outside* the building, falling into a trapped drain.

Note.—There should be no drains *in* the dairy or *under it.*

Ventilation.—There must at all times be ample ventilation. Ventilators at each end of the dairy near the floor, and one in the

centre of the ceiling, to conduct a continual flow of fresh air through the chambers.

Light.—*Not too strong*, as too strong a light falling upon the milk set for cream causes specks in the butter. Two good windows, double, and well glazed, are necessary. Dust and insects are kept out by inside blinds of fine gauze wire.

Temperature.—The greatest attention must at all times be paid to temperature, which should be as equable as possible, and under ready control. To attain this object, a good reliable thermometer should be hung up in the dairy, and the dairy constructed in such a manner that the heat can be shut out in *summer*, and the temperature raised in *winter* by the aid of hot-water pipes or a stove.

Note.—The dairy must not be too *dry*, or a hard crust will form on the cream; nor too *cold*, or the milk will absorb impurities from the atmosphere. The ideal temperature all the year round is from 55° to 60° F.

Water Supply.—A plentiful supply of *pure* cold water, whose source is reliable and protected from contamination.

Hot Water.—Provided by a boiler in a small outer room adjoining the churn-room, to which hot-water pipes may be attached to raise temperature of dairy in winter.

Shelving.—Of slate, marble, or stone.

Equipment.—For small dairy, of not more than twenty cows, will depend very much on the accompanying circumstances, and either of the following appliances will be necessary for *raising the cream*:—

1. Set of shallow pans for open-air setting.
2. Jersey, Dorset, or Richmond creamer.

(*Note.*—These pans are great improvements on the old shallow-pan system).

3. Swartz cans } For deep-setting systems.
4. Cooley cans }
5. Mechanical separator.

A Dairy of more than Twenty Cows is best equipped with a separator, and small steam or gas engine. This power can, at the same time, turn the churn and butter-worker, which should be connected with the shaft by means of pulleys.

Where there is a sale for skim milk and fresh cream, a separator is invaluable.

Small Dairies.—Where butter-making is the primary object, and the skim milk used on the farm, either of the following deep-setting systems or the Jersey creamer will give very good results, if properly carried out.

Churns.—Well made of oak, no inside fixtures, easily cleaned,

large opening, glass in lid, and ventilator. Desideratum of a churn is maximum of *concussion* and minimum of *friction*. Bradford's "Diaphragm" or 'Charlemont," Llewellyn's "Triangular," and Hathaway's "End-over-end" churns are excellent in this respect, for hand or power.

Butter-worker. — Bradford's "Arch Albany," with helical roller; or, for *power*, the "Armentine," with helical roller.

Butter-board.—For making butter up on.

Scotch Hands.—For making up butter, which should never be touched with human hands.

Refrigerator (Lawrence's "Capillary").—For aërating and cooling milk. A most useful process for preserving milk, as soon as it leaves the cow, when required to be sent on long journeys by rail.

Butter scoop.—To lift the butter from the churn.

Skimmer.—For creaming.

Strainer (with wire-gauze sides).—For milk.

Milk-ladder.—To rest strainer on.

Cream-crock (Porcelain or Glass).

Dairy Thermometer (of Glass).—For ascertaining the temperature of cream and milk.

Salter's Balance.—For weighing milk.

Scales and Weights (of china).—For weighing butter.

Cream-testers.—For showing percentage of cream in the milk of each cow.

Creamometer.—For showing percentage of cream.

Lactometer.—Showing *specific gravity* of milk; to be used with **Creamometer** in testing the quality of milk.

Milk and Cream-pails.—Tinned steel and enamelled sheet iron.

Milk-measures.

Temperature Cans.—For regulating temperature of cream in winter and summer.

Butter-cloth and **Litmus Paper.**

Cream-raising and Management.

Cream is made up of fat globules, extremely small in size, which, being lighter than the serum or watery part of milk, rise to the surface when the milk is at rest, and form cream.

Raising Cream.—The form and size of utensils and appliances for separating the cream from the milk must have reference to the accompanying circumstances, and strict attention must be paid to general rules, whichever method is adopted to accomplish successfully complete and effectual separation.

Systems of Setting for Cream.—The open-air shallow-pan

system is the most common, but does not give the best results, for, in order to get the largest *quantity* of cream, the milk has to stand too long, and thus the *quality* of the butter is endangered. Cream rises more rapidly in a falling temperature. The "Jersey," "Dorset," and "Richmond" creamers are constructed on this principle: the pans have double sides and bottoms, and are fitted with lids that assist the rising of the cream. By the use of boiling and cold water in the spaces, the temperature of the milk is raised and lowered as desired.

The Jersey Creamer.—The temperature of the milk is first raised about 50° F. above that of the water used for cooling, *e.g.* water 60° F., milk 110° F. As a steadily falling temperature is necessary to the success of this system, the cooling must not be *too rapid*, and the cold water should be allowed to circulate around the pans until the temperature of the milk has fallen to that of the water. The effect of this treatment will be to bring all the cream to the surface in twelve or fifteen hours, the cream and skim milk being both fresh and sweet, which is a great advantage. These creamers are sound in principle and effective in operation.

Cooley System.—The apparatus consists of a tank of water with inlet and overflow pipes. In this tank the milk-cans are totally submerged. The cans used are about twenty inches long and eight and a half inches diameter, fitted with syphon tubes, and holding about sixteen quarts. These are fitted with lids, which are fastened down, the air under the rims of the covers preventing the passage of any water into the milk. The apparatus is very simple, takes up little room, produces uniform results, and raises the cream in the shortest possible time. This method gives, also, sweet cream and sweet skim milk, and can be employed with best results in small dairies.

Swartz Cans.—Oval cans, two feet deep, which, when filled, are placed in a brick, stone, or cement tank, the depth of the cans (*i.e.* two feet), and supplied with iced or running cold water. If the temperature of this water can be kept, summer and winter, at 40° F. to 50° F., the cream rises in twelve hours. The success of these systems is dependent upon regulation of temperature, and a plentiful supply of cold water, 40 to 50° F. If this can be accomplished, first-class results may be obtained.

Devonshire System.—This system is an advantage in small dairies and in hot or "thundery" weather, when the milk should be scalded immediately after milking. If the milk be *allowed to boil*, the butter will not be so good, but rough to the tongue and flavourless. If the milk is in the slightest degree sour, heat will cause it to turn to curds and whey.

Clotted Cream is generally associated with Devonshire dairying, and "Devonshire cream" is noted for its delicious flavour. It can easily be produced, and profitably sold in little glazed earthenware jars.

The method is to set the milk in pans, from four to six inches deep, upon a stove specially designed for the purpose, and *gradually* heat to 170° F., the time occupied being two hours and a half. When a blister ring appears on the surface, the pans are removed, and set in a shallow tank of running water for twelve hours longer. When skimmed the cream is rich and thick.

Mechanical Separation.

The Separator.—Where a large quantity of milk has to be dealt with, there is no better method than mechanical separation: perfectly fresh cream and equally fresh skim milk can be immediately obtained by its use; space, time, and labour being all greatly economized, and a larger percentage of butter fat being obtained from the milk than by any other method of separation. These machines have been brought to the greatest perfection, and provision is made for regulating the *thickness* or thinness of the cream (a matter of much importance). The names of some of the best are the "Laval," "Alexandra," "Victoria," and "Danish." They all act upon the same principle (viz. centrifugal force), and the separators mentioned are excellent for the simplicity of their mechanism and uniformity of results.

Method of using.—The milk is fed into a drum or cylinder revolving on a spindle. The velocity with which this drum rotates causes the fat or cream to separate from the watery part of the milk, which, being the heavier, flies to the outside of the cylinder, while the lighter part (the cream) gathers to the centre. Fresh milk enters, and, being separated, forces that already separated to make its escape, which it does by means of two tubes, one for the cream and one for the separated milk. If the cream has to be sent away, it should be immediately passed over one of Lawrence's refrigerators, and the separated milk should either be scalded and then cooled by a refrigerator or passed over a refrigerator at once. *The quantity of milk separated* depends upon the size of the machine and speed at which it is driven. Their capacity for separation ranges from 20 to 90 gallons per hour for hand separators; to 350 gallons per hour, power machines. *The successful management* of the separator is subject to certain rules of temperature and speed, and if these rules be neglected, separation will not be complete or satisfactory. A correct and even speed must be maintained with proper control of milk supply, and regulation of the temperature of the milk.

Cream Cheese.—Cream cheese is easily made; there is less skill in making it than any other cheese: but success does not always attend the first trial of its manufacture. It is made from thick fresh cream, carefully drained, pressed, and ripened. It resembles the soft cheeses of France in appearance and consistency. Where there is a demand, its manufacture will be attended with considerable profit, a given quantity of cream yielding more cream cheese than butter. Cream cheese contains a portion of casein, which adds to the profit, whereas butter should contain no casein at all.

Cream Ripening.

The Term "Ripening" is used to denote a certain mellowing of the cream, attained by keeping it some time before churning. Whatever system of creaming is adopted, it is of the utmost importance that the cream should be perfectly sweet when taken from the milk; but, in order to obtain a large quantity of butter, it is best to ripen the cream by keeping. The full flavour is developed and the butter keeps longer.

Causes of Ripening.—The ripening of cream is caused by the presence of minute living organisms called "bacteria," which attack the milk and cream, and produce chemical changes which are very powerful in affecting dairy operations, and, up to a certain point, very useful; but great care must be taken to stop the work of these ferments at the proper stage, *i.e.* when the cream is in the most desirable state for churning. The action of one organism is to attack the *lactose* or *milk sugar*, and convert it into *lactic acid;* and of another, to attack the casein, or curd of the milk, decompose it, and make it soft. If ripening goes too far, putrid decomposition commences. These organisms work and multiply best at a temperature of 97° F. The duration of their life is thirty-six hours, and after that time other ferments take their place, acting on the fats contained in the cream globules, to the detriment of the cream, by changing the butyrine, the chief ingredient of the volatile oils that give the delicious flavour to butter, into butyric acid. It is for this reason that, when cream is allowed to be kept too long, the butter becomes rancid, and will not keep. The necessity for churning often, is obvious.

In hot weather, "ripening" may be retarded by placing the cream-crock in cold or iced water in a cool place, whenever the temperature of the air is above 55° F.; if kept at 40° F. to 50° F., ripening will proceed very slowly; at 65° to 70°, very rapidly; 60° F. is the best temperature for ripening cream.

Butter-making.

To obtain good butter we must have good cream, and good cream depends upon good milk and its proper management. The quality of milk depends upon the breed, individuality, feeding, and treatment of the animal.

Butter-making is an art that needs the application of sound principles, and must be pursued from beginning to end with system, regularity, watchfulness, intelligence, and attention to *trifling details.* They say "trifles make the sum of human happiness or woe," so trifles just as inconsiderable make or mar success in *butter-making.* Objections will be raised, and many may say that butter could be made quicker and with less trouble on the old system; but the monetary value of dairy produce is greatly increased by its *superior quality.* Time and labour is usefully expended when we can compete profitably with the foreigner, and raise our profits on a level with his. This should be a great inducement for the better manufacture of butter. *Mechanical aids to butter-making* are of great value, and there is as great a necessity for having a dairy *properly equipped* as there is for the employment of time- and labour-saving implements in other branches of agriculture.

The necessity for the greatest cleanliness in everything appertaining to the dairy and the operations of butter-making cannot be too emphatically dwelt upon, and regulation of temperature with the use of a *thermometer* is a vitally important point. Good butter-makers know that the question of temperature has a most essential bearing upon successful butter-making.

It may appear unnecessary to point out that slight differences in temperature, the speed of churning, the keeping of the cream, and the quality of the milk, make vast differences in the quality of the butter. The system we propose describing is one that has been perfected by those who have carefully studied and worked it out in its smallest details, by comparison with home and foreign manufactures, by skilled and scientific labour, with time, opportunity, science, and money to assist in the investigation. To give an idea of the merits of this system, it is necessary to call attention to three important points on butter-making: (1) The necessity of *removing as completely as possible the casein,* or curdy matter; for if any portion of this matter remains in the butter it affects its *keeping qualities,* the casein being the first to decompose. (2) *The preservation of the grain.* Any injury to the grain of the butter takes away the fine flavour which should characterize it, and injures its appearance and keeping qualities. The third important point is to *salt the butter properly and uniformly.* These

are the three most important points, and the system described will show how to reach the maximum degree on these points.

Old Method.—*The old-fashioned way of making butter* is to churn it into a lump; but by this means a large quantity of butter-milk is gathered in the butter, contrary to the first requisite in butter-making, which is that we should have it *as free as possible from casein or cheesy matter.*

In the process of churning, the fat globules are brought into close contact, and united together to form small grains, continually increasing in size as the churning proceeds. Now, the chief object is to get away the fat without having any casein in it, but by churning the butter into a lump a large quantity of butter-milk and casein is included. The watery part may be worked out, but not the casein; and if the cream has been in any way tainted, the taint will remain in the butter instead of in the butter-milk. Nor does the mischief rest here, for the dairy-maid is obliged to work the butter considerably with the hands before she can squeeze out the excess of moisture. Two evils result from this. First, the grain is injured by excessive working; secondly, the butter is tainted by coming in contact with the perspiring hand. Again, to salt the butter evenly when it is gathered into a lump, it must be spread out in layers and worked again, and thus further injury is done to its quality and keeping properties.

Improved Method.—According to the improved method, notice is taken as soon as the cream "breaks," and the churning is continued a little until the butter resembles meal and water. The churn is then stopped, and a small quantity of cold water added, to reduce the temperature of the butter at that stage when it is most required, and to prevent the gathering of the granules into lumps. By keeping them separate they are more easily freed from the butter-milk, and the grain is much improved. The plan of adding cold water at this stage was pursued long ago by many of the most successful butter-makers, who kept it a profound secret. The churning is then continued carefully until the butter is in a granular form, like pin-heads or mustard seed, when the churn is finally stopped, and the butter-milk drawn off.

In this fine condition the butter can be most readily freed from its casein, or cheesy matter, by washing. The butter is also in its best form for salting by brine, as each granule of butter can have its own thin coating of salt. And now the three most important points in butter-making have by this method been arrived at, *i.e.*—

1. The removal of the casein.
2. The preservation of the grain.

3. Uniformity of salting.

It is an interesting fact to know that many of those who have been most successful in obtaining prizes at agricultural shows *do not wash their butter at all.* Such butter retains a far better flavour for a few days, but soon becomes rancid.

Preparation of Utensils.—*Before use.* (1) Wash with cold water; (2) with boiling water; (3) scrub with salt; (4) rinse with cold water in summer and warm in winter.

After use. (1) Rinse with cold; (2) with boiling; (3) leave dry, well exposed to the air. In the case of a churn, the lid must be left off.

Preparation of Cream.—1. Take temperature of cream with glass dairy thermometer, and compare it with one hanging up in the dairy which registers the temperature of surrounding air. 2. Decide temperature at which to churn by that of surrounding air. The ideal temperature of the churning-room all the year round is 58° Fahr. The higher the temperature of the atmosphere, the lower the temperature of the cream must be for churning. Thus:—

Temperature of Air.	Temperature of Cream.
66° F.	54° F.
64°	55°
62°	56°
60°	57°
58°	58°
56°	59°
54°	60°
52°	61°
50°	62°

Should the cream be thin and sweet, it may be churned at a higher temperature than when thick and ripened. The temperature of the cream to be churned should not, under any circumstances, exceed 64°, or be below 53°.

To lower the temperature of cream, (1) place the vessel holding the cream in a tank or cistern of cold water the night before, if the temperature be below 55°, and the cream above 60° Fahr.; (2) further reduce it by means of a *temperature-can* filled with *iced or cold* water stirred about in the cream, or place the vessel containing the cream in another containing cold or iced water.

To raise the temperature, (1) place the vessel holding the cream in another containing *hot* water, and *gradually* heat it to the desired temperature, always keeping the cream stirred, or use a temperature-can filled with hot water.

Carefully thin the cream with a little water if it be very thick and rich.

After regulating temperature, strain the cream through a muslin tied over a cream-can, stirring gently and squeezing through with Scotch hand, allowing a degree or two for loss of heat, according to temperature, during the process.

Churning.—All preparations being completed, pour the cream into the churn (never more than half filling it), and begin churning *slowly*.

During the first five minutes ventilate the churn by pressing the vent, or removing the plug at every ten or twelve revolutions. This lets out the gases set free by the concussion, and expanded by rise of temperature, which, if retained, will interfere with the churning.

Increase the speed after the first five minutes to a steady uniform motion, regulating the speed according to the size and nature of the churn. A steady, uniform motion is best for all purposes, as *concussion*, not *friction*, should be the aim of churning, otherwise the delicate flavouring oils of the butter, which are volatile, will escape, and the butter suffer in consequence. The object of churning is to obtain the *butter-fat* granules, free of *caseous matter*, and whole, or nearly so. This constitutes the *grain* of butter, and in this condition it has its best flavouring and keeping qualities.

The churn should be *stopped as soon as the butter granules begin to be visible*, and can be seen, on the glass, resembling oat meal and water. The lid should be removed, and temperature of churn taken. Pour in cold water: quantity—one quart, more or less (according to the temperature of the churn), for each gallon of cream. In winter, if the temperature of the air be below 52° F., the temperature of the water added should not be below 48° or 50°F.; in summer, not above 45°F. if the air be above 60°F.

After the addition of the water, replace the lid, and churn on *most carefully* until the butter granules are about the size of *pin-heads* or *turnip seed*.

Draw off the butter-milk, using a hair-sieve to catch any stray particles of butter that may escape with it, and return them to the churn.

Proceed to wash the butter, the temperature of water used being in summer 45°F., and in winter not lower than 50°F.; if the air be below 52°F., use for each washing rather more water than you had cream in the first place, and dissolve half a pound of pure dairy salt in the first washing, to get rid of the butter-milk and solidify the granules of butter. Strain the water through a muslin strainer. Gently oscillate the churn, or turn five or six times, and draw off the water, using a hair sieve. Wash until the water runs off quite clear: three washings should suffice. Great care must be taken

not to over-wash the butter; over-washing will injure the delicate flavouring and colour.

Salting the Butter with Brine.—Make a brine sufficient to cover the butter. The proportion of salt for each quart of water put into churn:—

Ordinary	salting,	½ lb.,	leave on	30	minutes.
Heavy	,,	1 lb.,	,,	30	,,
Light	,,	¼ lb.,	,,	4	,,

In removing the butter from the churn never touch it with the hands. Do not let off the brine before removing the butter on to the worker with a wooden scoop and hair sieve.

Working the Butter.—Proceed to work (being careful not to overload the worker) by pressing gently and firmly on and *forward* the form carrying the roller; at *the same time* turn the handle of the roller, avoiding a rubbing, grinding, or sliding motion. Reverse the handle, making the butter into a roll, and collect any stray particles with a small pad of the butter. Wipe the *roller* and *board* with a clean muslin when the moisture ceases to run off the table. Be careful not to *over*-work or *under*-work the butter. To ascertain if the butter be sufficiently worked, press one end gently with a Scotch hand. If moisture does not exude, if it is free from hollows and cavities, and breaks quite short with a granular fracture, it is sufficiently worked.

Weighing.—Remove from worker to butter-board (which carefully wipe with a damp cloth), and weigh into quantities required on scale with slab made of marble or glazed earthenware.

Making up.—If the butter be not *quite firm, do not attempt to make up*, but let it remain in a refrigerator or cool place for some hours, and then proceed to mould the butter with *a pair of Scotch hands*, upon a butter-board. (*Note.—Never touch with the hands.*) Be careful not to grind or rub the butter on the board, but keep turning it over and over, avoiding any unnecessary roughness or slapping. Hold the Scotch hands firmly and low down. A little practice will give great deftness, and a number of pretty designs may be made with the Scotch hands, or the butter may be stamped and moulded. Rolls and bricks are most convenient for packing. Whatever form is chosen for moulding the butter, it should be neat and distinctive.

Packing Butter.—The packing of butter should be neat, efficient, and pleasing to the eye, as it will greatly enhance its market value.

Vegetable parchment paper and small boxes of wood, perfectly free from smell and flavour, are the best for wrapping butter in for sale. In packing butter for sale, it is necessary to

guard (1) against it receiving any *foreign taste or infection* from the vessel in which it is packed; (2) against the effects of unfavourable temperature; (3) against damage and loss by soakage.

Bradford's small wooden butter-boxes are a great convenience, and, whilst preserving the print, prevent the butter from getting soft; and the more tasty and pleasing the form in which butter can be put in the market, the greater the price it will bring. The only objection is the extra weight for postage.

Rancidity and Bad Flavour in Butter.—The causes are:—

1. The decomposition of the casein, left in the butter. The casein should be removed when making the butter, by washing at the granular stage.

2. The formation of lactic acid from fermentation of lactose derived from the milk. The bacteria, causing the fermentation, may be killed by scalding the milk. Also wash the butter well, and keep in a cool place.

3. Bad flavour may be imparted by such foods as roots; to prevent this, boil the roots.

4. Tainting may be caused by contamination with sour milk, and by proximity to substances with disagreeable odours.

Points for judging Butter.

Flavour.—Nutty, aromatic, sweet	25
Keeping.—Slow to change its good qualities	20
Solidity.—Firm, not melting easily nor softening	10
Texture.—Closeness of *grain*, granular fracture, not greasy ..	25
Colour.—Natural and even	10
Make.—Cleanliness, freedom from moisture, salting, nicely put up	10
	100

Scale of Points for Butter-making Competitions.

British Dairy Farmers' Association.

Preparation of cream	4
Preparation of utensils	6
Ventilation of churn	4
Judgment and skill in churning	15
Use of strainer	4
Washing butter in churn	10
Use of thermometer..	7
Use of butter-worker	7
Salting	5
Making up	15
Rapidity and cleanliness	5
Flavour and colour of butter	7
Texture and freedom from moisture	7
Cleaning of utensils	4
	100

Cheese.

While butter consists almost entirely of various fats, cheese is a nitrogenous substance, consisting of the casein of the milk, with more or less butter-fat.

	Composition of Butter.	Composition of Cheese. Old Stilton.	Cheddar.
Water	11–15 per cent.	20	33
Fat	83–87 ,,	44	33
Casein	0·6–1 ,,	29	28
Milk sugar	0·2–0·7 ,,		
Ash	0·1–3 ,,	4	4

Manufacture of Cheddar Cheese.—We will here briefly describe the manufacture of Cheddar cheese; the principles are the same for most classes of cheese.

The milk is placed in a large vat and heated up to 86° F. This is done either by having a jacket around the vat, and passing steam between the two walls (the Canadian or Scotch method), or by taking out a certain amount of milk, heating it to a few degrees above the required temperature, and then returning it to the bulk in the vat (English or Harding method). Rennet is then added, at the rate of 4 ozs. to 100 gallons. The milk is stirred a little, and allowed to curdle for from 45 to 60 mins. The curd is next cut with curd-knives, and then left for 10 mins. more, after which the stirring and breaking proceeds for about 40 mins. The mass is then scalded, the temperature being raised gradually at the rate of about 1° in 4 mins., until it reaches 100°–103°. Stirring is continued until the curd is hard and falls quickly to the bottom of the vat; on squeezing it with the hand it should readily fall in pieces again. After settling for about 10 mins., it is pressed in the vat for the same time, then cut a little, collected together, and pressed again. The whey is now drawn off, the weights removed, and the mass cut into blocks. The curd is then wrapped up in clean muslin, the rack and weights are replaced, and the whole stands for 20 mins. It is then turned twice or thrice, cut into cubes of about 2 inches edge, tied up in the cloth, and pressed once more. In this state it must be kept warm for approximately 20 mins., and is then ground to a fine condition. After stirring for 15 mins., it is salted, the salt being added at the rate of 2 per cent. The mass is pressed in moulds for some time, and is then allowed to ripen, which takes about three months.

Cheese should be ripened at a temperature not exceeding 70° F. A considerable loss of water occurs during the operation, and also of fat and casein, if growth of mould takes place. It should be remembered that no part of the casein is changed into fat during ripening.

CHAPTER IX.

WOODS AND PLANTATIONS.

Forestry does not enter largely into the work of the ordinary agriculturist, but still a small plantation is often found on the farm.

Uses of Forests.

Trees are planted for three primary reasons: (*a*) profit, (*b*) shelter, (*c*) ornament.

(*a*) They are our sources of timber and lumber, and are also one of our chief sources of fuel. There is a very great demand every year for timber, for building and other purposes, necessitating a large importation from Canada, Russia, and several other countries. It is not to be expected that a farmer could meet this demand, but still there are many large waste tracts, as in the North of Scotland and many hilly districts in England, which would return a good profit if planted with suitable trees.

Charcoal is obtained from the wood in some places. The branches are piled up into large heaps, covered over well with turf, and then set on fire. Various gases are given off, and an impure mass of carbon remains.

The leaves and young twigs of trees are, to a certain extent, a source of potash salts. When burned they leave these compounds behind in the ash, from which they can be obtained by lixiviation.

(*b*) Trees are the natural protection from storms. If planted in suitable positions, such as the most exposed sides of the farm, they protect the crops from cold freezing winds, and hence enable them to get through the winter much better. On mountain sides, plantations of hardy trees may be made with advantage. Not only are they profitable in themselves, but they prevent cold blasts from sweeping down through the valleys, and thus assist vegetation to a more vigorous growth. On exposed sea-coasts, plantations of trees, commencing from fifty to a hundred yards

from high-water mark, are of great use in sheltering the land, and binding sandbanks.

It is very often advisable to have a ring of trees around the homestead, and thus all stormy winds are kept off. On hillsides with little protection, good sheep-folds may be formed by planting a circular band of trees. The sheep can be driven in here at nights for shelter if required.

(*c*) Nothing increases the beauty of a landscape more than plenty of well-formed trees. This is one reason why they should be planted about every mansion or farmhouse. They may also be grown along the sides of roads, when they will afford a pleasant shade. It is, however, not always advisable to have rows of trees along the fence line. Their roots spread out for considerable distances on each side, and, in consequence, drain away the plant-food, which would have been more profitably used up by the crop. The shade of the trees also causes the plants to be of less vigorous growth. For these reasons very few trees should be grown in arable fields, though on pastures they form a useful shade. In fields with permanent fences the best places for them are the corners.

Forests have, however, several other uses. They affect the climate of a country favourably in summer, causing the temperature during night and day to be more even. They retard the evaporation of water from the soil, thus keeping it always moist. Showers are also more frequent, though the annual rainfall is not much increased. To a certain extent, the trees purify the air, taking in carbonic acid gas and giving out oxygen during the day time. Forests are the principal sources of our streams, and they also cause them to flow steadily. The rain, when descending, is more or less checked in its fall by the leaves. Part is evaporated from the leaves, but most is absorbed into the loose, friable, vegetable soil, through which it readily percolates into the streams. The humidity of the air causes frequent falling of rain, and hence the brooks run regularly, and are not so much affected by drought.

When trees are totally removed from the land there (1) is a greater liability to excessive dryness of the soil, (2) greater extremes of temperature, (3) more destruction by winds.

Classes of Trees.

The different kinds of trees are divided into two classes—the Deciduous trees and the Conifers. The former shed their leaves in autumn; the latter are evergreen. Deciduous trees are, again, split up into Hard-wooded and Soft-wooded trees.

Hard-wooded Trees.—The chief genera of these are given in the following list:—

Common Name.	Botanical Name.	Natural Order.
Oak	Quercus	Cupuliferæ.
Elm	Ulmus	Ulmacæ.
Beech	Fagus	Cupuliferæ.
Ash	Fraxinus	Oleaceæ.
Sycamore, or Maple	Acer	Acerineæ.
Birch	Betula	Betulaceæ.
Alder	Alnus	Betulaceæ.
Hawthorn	Cratægus	Rosaceæ.
Holly	Ilex	Ilicineæ.
Walnut	Juglans	Amentaceæ.

There are very many varieties of these trees; thus there are above sixty distinct species of the oak.

Soft-wooded Trees.—These are much quicker in growth than the last, but much less durable. The chief genera are—

Common Name.	Botanical Name.	Natural Order.
Horse-chestnut	Æsculus	Sapindaceæ.
Willow	Salix	Salicaceæ.
Poplar	Populus	Salicaceæ.
Lime Tree	Tilia	Tiliaceæ.

Conifers.—The trees of the genus Pinus are the chief in this division. They are very numerous, as may be seen from any list.

Common Name.	Botanical Name.	Natural Order.
Scotch fir	Pinus sylvestris	Coniferæ.
Black Austrian pine	,, austriaca	,,
Red pine	,, resinosa	,,
Cluster pine	,, pinaster	,,
Stone pine	,, pinea	,,
Siberian pine	,, cembra	,,
Weymouth pine	,, strobus	,,
Norway spruce fir	Abies excelsa	,,
Black spruce fir	,, nigra	,,
Douglas fir	,, Douglasii	,,
Common silver fir	Picea pectinata	,,
Common European larch	Larix Europea	,,
Cedar of Lebanon	Cedrus Libani	,,
Common yew	Taxus baccata	,,
Cypress	Cupressus	,,

We will now consider a few points about the principal trees.

The Oak.—Grows very slowly. Develops best on deep, heavy soils. It is raised from the acorns, which are sown in autumn. Transplant when one year old. The timber is very hard and durable, and of great use for house-building, agricultural erections, and implements. It is a very profitable crop, and the demand for the timber is unlimited.

Elm.—Requires a deep, rich, dry loam. Propagated by suckers from old roots, or by layering. Grows rapidly, and attains a good height. The timber is much used in agriculture for troughs, and various purposes. It is strong in what is called lateral fibre, but is deficient in longitudinal adhesion. Good for pulley blocks, naves of wheels, and short frameworks.

Beech.—Grows well on dry chalky soils. The seeds are stored through winter and sown in March, in rows a good distance apart. Transplanted when two years old, in some fine weather between November and March. The young shoots are very slender; the leaves are of light colour; the bark very smooth. It is very hardy. The timber is of little value, being brittle and short-grained.

Ash.—Suits a loam best. It should be planted in somewhat sheltered positions, though it is a hardy tree. The wood is very tough and elastic; used for carriage-building. Greatest value of timber when from fifty to sixty years old. Propagated from seeds (samara), which are stored in sand for eighteen months, to rot off the outer coat. Sow in March; one seed to three square inches. Transplant to nursery rows the next spring, from which they are removed to the forest in two or three years.

Maple.—Suits all classes of soil, if fairly free from water. The timber is very good. Propagated from seeds, sown about October. Transplanted to nursery when one year old, where they remain two years.

Birch.—Grows well on cool moist soil, and is very hardy. It is not very durable; the timber soon decays; used for small turnery work, butter-barrels and clog soles.

Alder.—Does well on any soil, so long as there is an abundance of moisture. The timber is of use for clog soles, charcoal, and a few less important articles. Propagated chiefly from seed, but also from cuttings and layers of young wood. The seed is dried for two or three days in the sun, and then the scales rubbed off with the hands. Sown in March; remains a year in the seed-bed and one to two years in the nursery rows.

Walnut.—Requires a deep dry loam. The young wood is soft, white, and of little value. When the tree gets to be about

sixty years old, the timber is dark-coloured, solid, beautifully veined, and takes a high polish. The fruit also is of some value. Grown from seed.

Hawthorn.—Grows best on rich dry soil. It is very hardy. The wood is of a yellowish-white colour, fine-grained, and can be finely polished. It is not, however, obtained in very large quantities. The hawthorn is very useful for hedges; indeed, it is very often the only material employed. The seed should be gathered when perfectly ripe, and allowed to lie in heaps, mixed with fine dry sand, until the pulp has rotted off. After about fifteen months the seed is sown in beds of good mould, at the rate of one seed to one or two square inches. Cover with about half an inch of earth. Remove, when two years old, to the nursery, where they are planted in rows twelve inches apart, with two inches between each plant. After two years here they may be removed to the hedges.

Holly.—Needs a good dry loam, containing plenty of organic matter. The little wood obtained is used for cabinet-making. Usually grown from seed.

Horse-chestnut.—Requires a good, rich, dry loam, in a sheltered position. The wood is soft, and is only occasionally used, chiefly for flooring, bottoms of waggons, etc. It is very ornamental. Grown from seed, which is sown about October. The young plants are transplanted, when a year old, into rows, in which they remain for about a year.

Willow.—Should have a good, deep, moist soil, and requires to be sheltered. The wood is white, tough, and durable, and very useful for making carts, as it does not readily split. It is propagated from cuttings, which are planted in spring, and transplanted in autumn into the forests.

Poplar.—The soil suitable is a good strong loam, deep and moist. It grows rapidly and attains a large height. The wood is light and durable. Propagated from cuttings, layers, and suckers.

Lime Tree.—Thrives best on strong deep loam; requires to be sheltered. The wood is white in colour, of soft and close nature. Grown from layers, which, when a year old, are removed from the parent stock and remain in the nursery about two years.

Scotch Fir.—Grows best on dry, sandy soils, and is very hardy. The wood is of great value, and is used for a very large number of purposes. Propagated from seed. The cones are gathered in December, and dried in a timber-kiln at 110° F., taking care not to go above this. Remove after heating twelve hours, when the scales will be found to readily separate from the seed. Store in a dry cool place till sowing, which is done on a piece of fine light

ground, at the rate of two seeds per square inch. After a year the young plants are transplanted into the nursery rows, and, when from two to three years old, they are taken to young plantations.

Black Austrian Pine.—Suits a dry, light soil. Very hardy, and is well adapted for sheltering other trees. The timber is valuable. Grown in a similar manner to the Scotch fir.

Red Pine.—Requires a light, gravelly, well-sheltered soil. The wood has a close compact grain, and is very resinous. It makes very good timber, largely used in America in house-building. Propagated from seed, similar to Scotch fir.

Cluster Pine.—Requires a deep, dry, sandy soil, situated near the sea. The timber is soft, not durable, and of little value. It is, however, very hardy, and hence is very useful for protection, especially along the sea coast. Obtained from seed; sown in April, transplanted when a year old, and again, after another year, transplanted in May. When three years old they are planted in their permanent positions.

Stone Pine.—Needs deep, light, dry soils, well sheltered. It cannot bear close planting. The timber is not very useful, and the tree is only cultivated for effect.

Siberian Pine.—Hardy, and grows on nearly any soil. The timber is not of great value, but the tree answers well as a nurse.

Weymouth Pine.—Suits a deep, dry loam. The timber is largely used in house-building, though it is not so durable as the red pine. It grows to a great height. Propagated from seeds.

Norway Spruce Fir.—Grows best on cool, moist, sheltered land. The timber is very valuable, being nearly equal to the Scotch fir. It is propagated in a similar manner to that tree.

Black Spruce Fir.—Suits the same soil as the Norway spruce. The wood is strong, light, elastic, and durable. The seed is sown in April, remains for two years; then transplanted, and after from two to four years they may be planted. It is advisable to frequently transplant during that time.

Douglas Fir.—Grows on nearly any soil, if porous and moist enough. The timber is of good quality, grows very rapidly, and the tree is very ornamental. Sown in a similar manner to Scotch fir.

Silver Fir.—Requires a well-sheltered loam. It should not be allowed too much room, or the wood, which should be fine and close-grained, becomes open and soft. Propagated similarly to the spruce fir.

Larch.—Grows best on deep, porous, fairly dry soil, especially those with a gentle slope. The larch is very hardy, and thus suits high land. The wood is durable and tough, even when young, and is extensively used in agricultural work, especially for fences,

The trees are reared from seed in a similar manner to the Scotch fir.

Cedar.—Requires a dry open soil; it is very hardy. The timber is usually soft, and of very little value, except when grown in its native place. It is very ornamental, and the wood is often used in carving. The cones, which do not fall off the tree for a very long time, are gathered in spring, and the seeds taken out immediately. Sow in April, and transplant in the same way as the Scotch fir.

Yew.—Does best on a sheltered strong loam. The wood is hard, close, and fine-grained; elastic, splits readily, and is very durable. Propagated from seeds, which are gathered in October, washed free from the pulp which surrounds them, stored among sand for twelve to fifteen months, and then sown. Transplant in nursery rows when two years old.

Cypress.—There are very many varieties suiting different kinds of soil. The trees do not usually grow large enough to be of use as timber. It is, however, ornamental, and is readily propagated from cuttings.

Methods of Propagating Forest Trees.

The three principal methods are: (1) from the seeds, (2) from parts of living trees, such as cuttings, layers, etc., (3) from young plants, obtained from nurseries, where they have been reared by the two last ways, or from forests, where they have grown naturally from the seed.

1. **From Seed.**—When trees grow in a state of nature, they, as a rule, spring from seed. This method is often employed in nurseries. The seed should only be gathered from good healthy mature trees, at a fairly dry time, as moisture is apt to spoil the seed. The following table (p. 629) gives much useful information about sowing.

The ground in which the seeds are sown should be, as a rule, light, well cultivated, fine and dry. It should be turned once or twice in the autumn, and the seeds planted about January. In a nursery, about one hardwood should be planted to about thirteen larches and five pines. The ground should be well hoed between the rows, and no weeds ought to be allowed. Care must be taken not to hurt the young plants when hoeing.

2. **Cuttings.**—In this method, a suitable young shoot is cut off from the parent stock, and then put into the soil, which should be kept moist for some time. The willow is the chief tree propagated in this manner.

Layers.—This process is often employed in propagating the

elm. Young trees are planted in the nursery, and, when three or four years old, are cut down to within about four buds off the ground. From these, young shoots soon grow out, which, when about a year old, are gradually bent down and covered with earth. This part of the operation takes place in autumn. The shoots soon grow up out of the ground, and bear leaves and roots themselves. In about a year the part nearest the stump is gently cut through, and the young plants transplanted. The remainder of the branch should be cut off, and shoots will again grow from the places.

3. **By Transplanting.**—The age at which trees should be transplanted varies somewhat according to the kind of tree. They should be transplanted for the first time in spring, when the ground is fairly dry. The dead of winter is the worst period in all the year. The young tree should be lifted out of the soil as carefully as possible, taking care not to leave behind any of the fibrous roots, if possible. It should then be put in the ground again quickly, as long exposure to the air causes an injurious loss of moisture. It has been found that a light porous soil causes the number of fibrous roots to increase greatly. The ground should be kept very clean, and the trees, as a rule, should be well apart. Some trees, such as the willow, would not grow to any height if planted with too much room. In these cases, the thick planting causes them to grow up straight and tall. Other trees, such as the oak, ash, elm, will need to be transplanted several times before removing to their permanent places. This frequent transplanting, if carefully done, greatly increases the number of fibrous roots, and, consequently, the capability of the tree for obtaining nourishment from the soil.

Modes of Planting.—When the land is tolerably even, and capable of being ploughed and tilled, some definite order should be observed in planting. This allows the young trees to be easily attended to, and also enables more to be grown. The two chief orders of planting are the *Square* and the *Quincunx*. In the former the trees are set in rows, so that each is at the corner of a square. This does not mean that only squares of a particular tree are made. For example, a large square of oaks may be planted together with the ash, so that in the rows oaks and ashes alternate. In the centres larches or Scotch firs may be planted in the same order. They act as nurses, growing rapidly, and thus protecting the young oaks, which, on arriving at early maturity, are given more room by the cutting down of the nurses. In the second order a similar manner is followed, but a tree of the same kind as those at the corners is planted in the centre.

In the manner of inserting the young trees into the ground, two systems are followed. The first is by planting in pits, and is

Table in Reference to the Rearing of Nursery Stock (from Brown's "Forester").

Kind of Tree.	Time of Year when Seeds are Ripe.	Mode of preserving Seeds till sown.	Quantities of Seeds.	Will produce of Plants.	Manner of Sowing.	Depth at which Seeds should be sown.	Distance apart of Seeds when sown.	Age of Plants at removal from Seed-bed.	Age when fit to plant out into the Forest.
Oak.	November.	Should be sown when gathered.	1 bushel.	From 6000 to 8000 according to quality.	In rows 18 in. apart.	2 inches.	1 to every 3 square inches.	1 year.	4 years.
Elm.	May and June.	Will not preserve, but should be sown when gathered.	1 bushel.	From 5000 to 7000.	In rows 15 in. apart.	½ inch.	1 to every 2 square inches.	1 year.	3 years.
Ash.	End of October.	Keep in dry sand or light earth 18 months, in order to rot the outer coat.	1 bushel.	From 12,000 to 16,000.	In rows 15 in. apart.	¾ inch.	1 to every 3 square inches.	1 year.	3 years.
Beech.	End of October.	In dry sand or light earth.	1 bushel.	From 10,000 to 12,000.	In rows 15 in. apart.	¾ inch.	1 to every 2 square inches.	2 years.	4 years.
Alder.	End of October.	In a dry airy loft.	1 lb. wght of clean seed.	5000	In beds.	¼ inch.	1 to the square inch.	1 year.	3 years.
Birch.	October.	In a dry airy loft.	1 bushel of clean seed.	From 15,000 to 18,000.	In beds.	⅛ inch.	200 to the square foot.	1 year.	3 years.
Horse-chestnut.	October.	Should be sown when gathered.	1 bushel.	From 2000 to 3000.	In rows 18 in. apart.	2 inches.	1 to every 4 square inches.	1 year.	3 years.
Sweet-chestnut.	Seeds generally imported.	In a dry loft.	1 bushel.	3000	In rows 18 in. apart.	2 inches.	1 to every 4 square inches.	1 year.	3 years.
Norway maple.	Beginning of October.	Sown when gathered.	1 bushel.	From 10,000 to 15,000.	In rows 15 in. apart.	¾ inch.	1 to every 3 square inches.	1 year.	3 years.
Sycamore.	Middle of October.	Sown when gathered.	1 bushel.	From 10,000 to 15,000.	In rows 15 in. apart.	¾ inch.	1 to every 4 square inches.	1 year.	3 years.
Walnut.	Beginning of October.	Sown when gathered.	1 bushel.	From 4000 to 6000.	In rows 18 in. apart.	2 inches.	1 to every 4 square inches.	1 year.	3 to 4 years.
Holly.	November.	Should be rotted in a heap with sand for 16 months.	1 bushel of clean seed.	From 15,000 to 20,000.	In beds.	¼ inch.	1 to the square inch.	2 years.	5 years at least.
Hawthorn.	November.	Should be rotted in a heap with sand for 16 months.	1 bushel of clean seed.	From 15,000 to 18,000.	In beds.	½ inch.	1 to the square inch.	2 years.	4 years.
Scotch fir.	Nov. and Dec.	On shelves in dry airy loft.	1 lb. wght.	From 7000 to 10,000.	In beds.	¼ inch.	2 to the sq. in.	1 year.	3 years.
Larch.	November.	On shelves in a dry airy loft.	1 lb. weight of home seed.	From 2000 to 3000 only, a large proportion being generally bad.	In beds.	¼ inch.	2 to the square inch.	1 year.	From 2 to 3 years.
Norway spruce fir.	November.	On shelves in a dry airy loft.	1 lb. wght.	From 8000 to 10,000.	In beds.	¼ inch.	2 to the square inch.	2 years.	From 4 to 5 years.
Silver fir.	November.	On shelves in a dry airy loft.	1 lb. wght.	About 500.	In beds.	½ in. nearly.	2 to the square inch.	2 years.	5 years.
Pinaster.	Seeds generally imported	In a dry airy loft.	1 lb. wght.	From 500 to 800.	In beds.	¾ inch.	1 to the square inch.	1 year.	From 2 to 3 years.

employed for nearly all hardwoods, and any other trees above two and a half years old. The pits are dug by the spade, and are from nine to fifteen inches deep, and of a similar breadth. The young trees are put in these, generally exactly in the centre, or against the side. The earth is then pressed firmly around the tree, taking care not to get it too hard. The turf is then replaced. The second system is by Notching; a slit is made in the ground with a spade, and into it the tree is carefully inserted. The edges of the split are then pressed together. This method is chiefly employed in planting very young trees, and is only suitable for such.

The distance apart of the trees in planting varies greatly. On mountainous land, two and a half or three feet is quite enough; but on sheltered parts, hardwoods may be planted at ten feet apart, with nurses at three or four feet from each other.

Planting on Low-lying Ground.—The chief thing to remember in this, is to have the ground well drained. Hardwoods are especially suitable for these districts. The planting should be done in a regular order.

Planting on Rocky and Mountainous Land.—No regular order can generally be observed. When planting on a regular hillside, the trees should be set in rows parallel to the crown of the hill, as this tends to prevent the earth being washed away. Large forests are usually best, as then the trees gain more protection. Scotch firs, larches, Norway spruces, and other conifers are most suitable for these districts. The plants should always be strong healthy ones, as weak ones would soon die when exposed to the cold mountain blasts.

Planting for Shade.—For this, only occasional trees can be grown, and no masses except sometimes in the corner of a field. The trees suitable are the oak, elm, ash, beech, and linden. The walnut may sometimes be grown near a house.

Planting for Ornament.—If planted in a park, they are arranged in no regular order. The trees suitable are the oak, elm, chestnut, beech, birch, cedar, Norway spruce, silver fir. In towns, the trees are planted both for ornament and shade. The distance apart varies greatly, they should be protected with a wooden or iron guard. The best trees are the elm, chestnut, poplar, maple, and several others which do not spread too much. These trees also suit for planting along private roads or public highways. In this case the land should be well cultivated for one season, and levelled suitably. A proper roadway is left; the ground on each side is sown with grass, and then one or two rows of trees planted.

Planting to Hide Objects.—Trees are often planted for this purpose, some quick-growing and leafy kind being selected. The

maple, sweet chestnut, Douglas fir, Norway spruce, Austrian fir, the mammoth tree (*Sequoia gigantea*), poplar, Corsican pine, and Scotch fir are most suitable.

Planting of Wind-breaks.—Wind-breaks consist of lines of trees of varying thickness placed so as to protect the land from the wind as much as possible. They are very valuable for this purpose. Of course, only the hardy, quick-growing trees should be used. Among deciduous trees may be mentioned the elm, ash, and maple. The conifers are most suitable; the Norway spruce and the Scotch fir, but especially the former, answer very well. The trees should be planted as thickly as possible, and, when several kinds are used, the Norway spruce should be placed in the most exposed position. If possible, at least three or four rows of trees should be planted, but it is best to have the windbreak much thicker than this. The trees will thus become more largely developed, and any weak ones may be readily removed and fresh ones introduced. The ground should be well ploughed and tilled about a year before planting. The trees are then planted, in rows if possible, and the soil between the rows kept clean and loose until the trees are several feet high.

Planting near the Sea.—Trees are very important in protecting land from the storms. A wall, about five or six feet high, or a fence, is first made. The fence consists of a turf dyke, four feet high, on the top of which are wooden rails with fir branches interlaced. The land should be drained, and the trees may be planted in April, in pits three feet apart. A belt about two hundred yards broad should be planted. The most suitable trees are the cluster pine, Norway maple, sycamore, elm, birch, black Austrian pine, with the sea-buckthorn, broom and furze for underwood. The trees should be kept fairly well thinned, as otherwise they only grow into low thick bushes. When this belt has become well developed, other trees of less hardy character may be grown on the inside.

General Management of Trees.—Trees do not generally require much attention. The plantations should be kept clean and all dead branches removed. The leaves should not be allowed to accumulate in large heaps, and all undesirable undergrowth, weeds, etc., should be taken away. The weak trees and the nurses are gradually removed. Under twenty-five years of age, thinning should be slight, and confined to the regulation of the trees, so that they do not interfere with each other's growth; close rank should be aimed at, so as to gradually kill off the bottom branches, whilst preserving an unbroken canopy of top over the whole ground. This principle should be observed at all stages, whether the trees are removed as thinnings or timber.

Pruning will seldom require to be performed. The aim should be to remove all unnecessary branches, to get a large number of good young shoots, and to improve the appearance of the tree as much as possible. No large branches should ever be cut off a mature tree, for very important reasons. The sap exudes from the cut surface, and, unless there is a considerable length of the branch left bearing leaves, the stump rots. The vessels in the tree which lead to the branch are filled with stagnant sap, and become soft and dark-coloured, spoiling the value of the tree for timber considerably. When pruning is performed on a young tree, this does not take place, and, properly done, the operation is of great use. The lower branches are those which chiefly require to be removed, so that the tree may grow up tall and straight, and not acquire too much of a bushy form. Planting close together at first, and then judicious thinning as required, causes the trees to grow in a more desired form than almost any amount of pruning. No more injurious course could be pursued in the management of a plantation than to thin severely and at random. Sometimes the young tree dies down to the ground, and shoots spring out from the stump. In this case the strongest and straightest should be selected, and the rest cut away. The pruning may be done with a knife or saw, the latter being for larger branches. With the saw a cut of about an inch is first made on the under surface, so that when the bough is nearly cut through it may not break down and tear away the bark. In all cases an inch or two of the branch should be left on the tree. The cut branches should always be quickly removed from the plantation.

The best time for pruning is in spring and early summer, as then all wounds quickly heal up. June may be taken as the best month. When the trees are about twelve years old they will scarcely need any more pruning.

With conifers the process of pruning is somewhat modified; they never require pruning unless it is to remove a double leader. A point, which needs special remembrance when dealing with conifers, is to never allow any dead branches to remain upon the tree. They prevent the proper growth of surrounding branches, they are unsightly, and to some extent affect the health of the trce injuriously.

When about thirty years old, all the nurses will have been removed, the larches being generally left to the last. At about thirty-five years a considerable part of the ash trees will be cut down for making many agricultural articles, as handles of ploughs, etc. Five years after, most of the sycamores are removed, and at forty-five years the elms will follow. A few trees will be cut

down during the next forty or fifty years to make room for the greater development of the oaks. At a hundred years the best oaks will be cut down, and soon the rest will follow. When a tree is cut down, its stump will need to be removed, and at last the formation of a fresh plantation will commence again.

When trees are planted for ornament, as in a park, they do not require to be cut down as shown above; the old trees, indeed, are generally the most picturesque.

Plantations of conifers do not need to be thinned so much as those of hardwoods. The chief crop is cut when fifty to seventy years old, when they are most valuable, but they may often remain till a hundred years of age.

When trees get old, they sometimes have large holes in them, filled with decaying matter. These should be cleaned well out, as they injure the tree and also harbour insects. They ought then to be coated on the inside with tar.

Coppices.—This system allows of a rapid return of capital. The trees are left till about eighteen years old. They are then cut down close to the ground, and the stumps soon send out shoots, which are termed coppice-wood. The nurses are removed from the plantation when about fifteen years old, and five to ten years after, the coppice-wood is fit to be cut. It should be endeavoured to get the trees fairly tall and with a good regular width. Coppices must be kept as clear of weeds as possible. The wood is used (1) by coopers, (2) for charcoal, (3) for baskets. For 1, the oak, elm, ash, hazel, sycamore, maple, and chestnut are the chief; for 2, hazel, alder, birch, mountain-ash, poplar and lime tree; for 3, willows. The bark of some trees, especially the oak, is used in tanning. Small amounts of birch and larch bark are sometimes used. The bark is usually stripped in spring, as then it separates more readily from the stems. As a rule, about three feet of the bark is stripped, the operation being performed when the tree is still in the ground. A light cut is made round the stem two or three inches from the surface of the ground, in order to prevent the bark on the stump being torn away. A similar cut is made three feet higher, and the bark in this interval stripped off. The stem is then cut down at the bottom of the stripped part, generally with the saw. The bark should be taken off in one strip, if possible, and in order to loosen it from the wood of the smaller branches it may have to be beaten with a mallet. The bark should then be dried in the open air or in an airy shed: the operation takes ten to fourteen days; the quicker it dries the better. It is then stacked until sold. The tannin in the bark is the essential factor in the process of "tanning."

Osier Plantations.—The land should be cool and moist, and needs to be cultivated for a year previously. The cuttings (from fifteen to eighteen inches long) are planted in rows, eighteen inches apart, with fifteen inches between the sets. The shoots grow about eight feet long, and are cut every year or alternate year. The land requires to be kept free from weeds, and the stumps need cutting down occasionally.

Underwood in Plantations.—Two kinds of underwood may be mentioned: (1) low bushy trees, (2) shoots from stumps of large trees cut down. The chief kinds planted are the laurel, holly, privet, juniper, rhododendron, elder, Scotch rose, hazel, snowberry, dogwood, sea buckthorn. These, as a rule, prefer a loamy soil, though they vary as to the required degree of tenacity. They should be grown in masses of one kind with few trees around, that is, if for ornament or cover. The uses of underwood are: (1) they help, in conjunction with large trees, to shelter the land, and prevent cold winds from sweeping through the forests; (2) they act as covers for game; (3) they give a more picturesque appearance to a forest. The disadvantages are that, if close to the trees, they do not allow a free passage of air, and, by their great abundance of roots, may take up too much plant-food.

Grasses, etc., in Plantations.—The chief grasses suitable for growing in plantations are cocksfoot, and wood meadow grass, and some other less important ones.

Buckwheat is sometimes grown when the woods are fairly young. It is much liked by pheasants, for which it is a very good food. The seed is sown in any convenient place, and the produce is eaten by the birds as they think fit. Rye may also be used in the same way.

Uses to which Wood is put.—Most of the trees are, to some extent, valuable for their timber, but local circumstances should determine greatly the trees to be grown. Ash and elm are needed in coachbuilding, and for handles; larch (three to six inches diameter) for propwood in coal mines; Scotch fir, larch, and spruce for railway sleepers and deals. Oak, pine, elm and ash are used for waggons, and other purposes. Elms are used for coach naves, and several other purposes. The trees for coppice-wood have been mentioned. For hop-poles young larches, about twenty feet long, are needed.

Timber.—The trees should be planted rather thickly at first, and then gradually thinned. This causes the stems to grow to a good height, and with plenty of thinning thickness is also secured. A dry porous soil favours root distribution. Enough room must always be given for the full development of the tree.

It must be remembered never to remove the nurses too suddenly. All the conifers, and especially the larch, require plenty of room. The forests always need to be kept clean of weeds, dead branches, etc.

In felling timber the trees should be cut down as close to the ground as possible. A greater amount is thus obtained, and the surface is kept even. The age at which to fell has been stated before (pp. 632, 633). If possible, the grower should sell the produce to the timber-merchant with the regulation that the latter must fell it.

The timber, soon after felling, should be cut up at the saw-mill into convenient lengths of planks, if required. These planks are then stored for from eighteen months to two years in a dry airy shed, in order to dry, or, as it is called, to season, as when used full of sap it is softer and more apt to decay. When for railway sleepers and other thick articles, it should be cut up into the proper form, and dried for a longer time than stated before.

In order to preserve timber better, various methods are employed, to which we shall briefly refer. A great tank should be filled with a solution of slaked lime or of common salt, and into this the planks are placed, for about ten or twelve days in the former case, and a week in the latter. The following method is given by Dr. Brown :—Dissolve 1 lb. sulphate of copper in 1 gallon boiling water, add 5 gallons cold water, mix well, and add 1 lb. sulphuric acid. Steep the well-seasoned timber for about twenty-four hours in this. Croggan's black varnish is also recommended for painting the timber with. Coal-tar, creosote, and carbolic acid (which is contained in the other two) are often used for preserving wood. It is well known that palings painted with coal tar last a much longer time than without it. Posts, before being put in the ground, should be dipped in tar. Not only the part which has to go into the soil, but at least four or six inches above the surface may be thus coated with advantage.

Judging Land by the Trees.—Land may, to a certain extent, be judged by the trees found growing on it, and this is especially useful in winter. When a tree is seen to flourish very much, it may generally be taken for granted that it is growing on the soil most suitable to it. The elm, oak, sycamore, ash, walnut, mulberry, and hawthorn grow on good soils only to their average height. The beech, Scotch fir, spruce, birch, poplar, blackthorn, alder, indicate poor land as a rule, although they may be well grown. These observations apply chiefly to naturally growing trees.

Marks of a Failing Tree.—When the foliage is of a dark green colour, and of a fair size, the branch-growth extending uniformly all over the tree, and the annual terminal growths of fair lengths,

the tree is growing, laying on timber in its trunk, and increasing in value; whereas, if the tree is failing, the foliage is pale, small, and poor, the terminal annual growths short and feeble, and the trunk increases at a very slow rate.

When the extremities of the branches are dying off, showing dead twigs, decay has set in, and the tree is then either standing still in value, or actually losing value every year.

Valuing Timber.—Many proprietors sell their timber standing, to save risk and expense. This mode of sale requires very careful valuation on the part of the seller, in order to find the cubical contents of the lot and their quality.

All trees under ten cubic feet contents are classed as "poles." These are too little in girth to saw up usefully, and necessarily fetch a low price.

Poles need only be counted and their contents averaged. The average is obtained by measuring about half a score, chosen haphazard in different parts of the wood.

Trees should be set out one by one by some one in a book, which is ruled in columns showing the number of the tree, kind, length, quarter girth, and cubical contents.

Practical foresters, in estimating the contents of a fallen piece of timber, take the length and the quarter girth measured about halfway between the butt and the small end. The quarter girth squared, multiplied by the length, equals the cubical contents.

E.g. Find the cubical contents of a piece of timber 18 feet long, and whose mid girth is 36 inches.

$$\text{Girth} = 9 \text{ in.} = \tfrac{9}{12} \text{ ft.}$$
$$\text{Length} = 18 \text{ ft.}$$

$$\text{Cubical contents} = \left(\frac{9}{\underset{4}{\cancel{12}}} \times \frac{9}{\underset{2}{\cancel{12}}} \times \frac{\overset{3}{\cancel{18}}}{1}\right) \text{ cub. ft.}$$
$$= \tfrac{81}{8} = 10\tfrac{1}{8} \text{ cub. ft.}$$

The price per cubic foot varies with the demand, but for some thirty years back good sound oak of fair size has averaged from 2*s.* to 3*s.*, many times even 4*s.*, per cubit foot in the wood.

Ash, 1*s.*, 2*s.*, and 2*s.* 6*d.*

Beech, 8*d.* to 1*s.*

Birch, 9*d.* to 1*s.* 6*d.*

Sycamore, according to girth, 8*d.* to 3*s.*

In conclusion, it may be stated that timber-growing is not, at present, considered a profitable investment in England, owing to (*a*) foreign competition, (*b*) high cost of production, (*c*) the long period that must elapse before returns can be expected.

CHAPTER X.

FRUIT CULTURE.

Fruit-growing.—It is well known that enormous quantities of fruit are imported into this country yearly, which might be profitably grown at home. As a rule, farmers pay too little attention to their orchards, and allow the trees to become overgrown with moss and to flourish unpruned. English fruit, properly grown, brings quite as good, and often a better, price than that from foreign countries, and yet the supply cannot adequately meet the demand. The culture of fruit-trees is both profitable and pleasurable.

Kinds of Fruit.—The apple (*Pyrus malus*) is most largely grown, for both table or kitchen use and for cider. It has been derived from the common crab. The Pear (*Pyrus communis*) is used more for dessert. The Plum (*Prunus domestica*) and Cherry (*Prunus* sp.) are less frequently cultivated. Peaches, nectarines, and such-like fruit are only grown, as a rule, in private gardens. The term "small fruit," is applied to the Gooseberry (*Ribes grossularia*), Raspberry (*Rubus idæus*), Black Currant (*Ribes nigrum*), Red and White Currants (*Ribes rubrum*). The apple, pear, plum, cherry, strawberry (*Fragraria*), and raspberry belong to the Rosaceæ, the gooseberry and currants to the Saxifragaceæ.

Soil and Climate suitable for Various Fruits.—Each kind of fruit has usually a certain soil in which it will flourish best. A few particulars about these are given below.

Apples.—A medium loam, with a clay subsoil. Soils overlying the chalk are suitable if there be three or four feet of earth above the rock. Low or wet land, near to large bodies of water, or much exposed, should be avoided.

Pears.—If grafted on a pear stock, a light loam with gravelly subsoil is most suitable; if on a quince stock, medium loam and clay subsoil.

Plums.—Light sandy soil, subsoil light. Do well on chalk with a few feet of strong loam above.

Cherries.—Good loam, with a chalk subsoil.

Filberts and Cobs.—Good porous loam, which may have rocky surface. Suit shaded places.

Gooseberries.—Rich sandy loam, with a somewhat gravelly subsoil.

Currants.—Light to heavy loam, subsoil gravel or clay.

Black Currants.—Do well often on heavy land, even when low-lying and wet.

Raspberries.—Light or medium loam, with open gravelly subsoil.

Strawberries.—Good rich loam upon cool gravel or chalk. They grow very poorly on a dry sandy or chalky soil.

Cold, wet soils produce unsized fruit, generally much spotted with fungus. Chalky soils will only do for bush fruits and cherries, except there be enough top loam to make three or four feet depth of soil. Gravelly soils produce fine fruit if deep enough and not too sandy. Loams are the best soils, and where it is mixed with stones almost all fruits do well. To put it briefly, any soil that will grow potatoes *well* will grow fruit well. With good garden cultivation nearly any kind of soil will grow fruit, but in growing for the market this course proves very expensive. For cider, the fruit from limestone and chalk soils is useless; from heavy soils and from ironstone districts it is best. When an orchard is at the bottom of a valley, the frosts often cut off the early blossoms.

Preparation of the Ground.—To begin with, the land should first be well drained, the lines of pipes being so arranged that they come about midway between the standard trees. They are thus least liable to be blocked up by roots. The surplus amount of water in the soil does not allow the roots to spread deeply, and encourages the growth of moss and lichens on the trees. The land should be well stirred up with a cultivator, but before this it is generally best to plough and subsoil plough. The breaking up of the subsoil gives greater room for the extension of roots, assists drainage, and allows free percolation of the air. Get the ground as clear of weeds as possible, as it will save much trouble afterwards. If a large field is to be converted into an orchard, it is best to take a root crop the previous year. The land would be clean, and contain a considerable amount of manure.

It is, as a rule, best to select ground with a slight slope to the south-west. Steep land does not allow of as many trees being grown, and is generally inconvenient. Shelter sometimes has to be provided by a line or two of trees to the north and east, at thirty or forty feet distance from the fruit-trees.

Manures.—A good dressing of farmyard manure may be

ploughed in during the previous autumn, so as to get well mixed with the soil. The application of slaked lime will probably prove beneficial. Lime is by far the most important ash constituent of the tree, and a considerable amount is always needed. It strengthens the stem, shortens the period of growth often, and causes the fruit to ripen earlier. It is especially useful for stone fruit, such as the cherry. Nitrogenous and phosphatic manures may be applied to poor soils, but a superabundance encourages the growth of rank wood. Ferrous sulphate in small quantities is said to produce a brighter colour in many fruits.

Fruit-trees to plant.—Some varieties of fruit-trees may be found very suitable in certain districts, and prove unprofitable in others. Before selecting fruit-trees the following points should be considered:—

1. The special line of culture.
2. The markets. Grow only such fruit as will pay well.
3. Whether for late or early markets, or both.
4. Whether growing for jam-making or other preserve.
5. Varieties adapted to the soil and climate.

The following table gives a few characteristics of some of the principal kinds of fruit. By "standard" is meant the large varieties; "bush" fruits are not so tall.

Variety.	Use. Kitchen.	Use. Table.	Comparative Quality.	Time when used.	Habit.	General Remarks.
APPLES.						
(1) *Standard.*						
Blenheim Orange ..	K.	T.	Good	Nov. to Feb.	Spreading	Takes 8 years to come to bearing.
Cox's Orange Pippin	—	T.	Very good	Oct. to Feb.	Spreading	Best dessert apples.
Duchess of Oldenburg	K.	T.	Fair	Aug. to Sept.	Spreading	Great bearer; early.
Ecklinville Seedling	K.	—	Good, but soft	Sept. to Oct.	Upright	Hardy.
Golden Noble ..	K.	—	Very good	Oct. to Dec.	Spreading	Vigorous grower.
King of Pippins ..	—	T.	Very good	Oct. to Jan.	Upright	Good bearer.
Norfolk Beefing ..	K.	—	Fair	Nov. to July	Upright	Very late.
Pott's Seedling ..	K.	—	Good	Aug. to Sep.	Upright	Vigorous grower.
Warner's King ..	K.	—	Good, very large	Oct. to Dec.	Spreading	Vigorous grower.
Wellington	K.	—	Very good	Dec. to April	Spreading	Very late.
(2) *Bush.*						
Cellini	K.	T.	Good	Sept. to Oct.	—	Very early, but sometimes cankered.
Frogmore Prolific ..	K.	T.	Very good	Oct.	—	Vigorous grower.
Keswick Codlin ..	K.	—	Good	Aug. to Sept.	—	Early and prolific bearer.
Lord Derby	K.	—	Fair; greenish colour	Nov.	—	Prolific bearer.

Variety.	Use. Kitchen.	Use. Table.	Comparative Quality.	Time when used.	Habit.	General Remarks.
Lord Suffield ..	K.	—	Very good	Aug. to Sept.	—	Very good tree except on thin or heavy soils.
Lane's Prince Albert	K.	—	Very good	Oct. to Jan.	—	Gives fine large fruit.
Stirling Castle ..	K.	—	Good	Sept.	—	Prolific and early bearer.
PEARS.						
(1) *Standard.*						
Beurré Bosc	—	T.	Rich and melting	Oct. to Nov.	Spreading	Large pear.
Beurré Hardy ..	—	T.	Rich and juicy	Oct.	Upright	Vigorous grower; medium-sized pear.
Clapp's Favourite ..	—	T.	Good, handsome	Aug. to Sept.	Upright	Vigorous grower.
Conseiller de la Cœur	—	T.	Rich and melting	Oct. to Nov.	Spreading	Vigorous grower.
Glout Morceau ..	—	T.	Flesh white, tender, and juicy	Dec. to Jan.	Spreading	Moderate grower.
Jersey Gratioli ..	—	T.	Rich, sugary	Sept. to Oct.	Upright	Early.
Louise Bonne de Jersey	—	T.	Very good	Oct.	Upright	Handsome fruit, good bearer.
Catillac	K.	—	Stewing pears.			
St. Germain (Uvedale's)	K.	—	Stewing pears.			
(2) *Bush.*						
Doyenne Boussoch..	—	T.	Fair quality, handsome	Sept.	Bush	Very prolific.
Doyenne du Comice	—	T.	Very good	Nov.	Upright	Moderate bearer, but very fine fruit.
Durandeau ..	—	T.	Very good	Nov.	Upright	Large fruit.
Pitmaston Duchesse	—	T.	Very good	Oct. to Nov.	Bush	Very fine pear.
Marie Louise d'Uccle	—	T.	Very good	Oct.	Pyramid	Hardy; good bearer.
Williams' Bon Chrétien	—	T.	Very good	Aug. to Sept.	Upright	Good grower; fine white-fleshed fruit.
PLUMS.						
(1) *Standard.*						
Czar	K.	—	Good, rich	July and Aug.	Upright	Great bearer.
Gisborne's	K.	—	Fair	Sept.	Upright	Great bearer.
Early Orleans ..	K.	—	Good	Aug.	Spreading	Very hardy.
Pond's Seedling ..	K.	—	Large, good	Sept.	Upright	Good grower.
Prince Englebert ..	K.	T.	Very good	Sept.	Upright	Great bearer.
Victoria	K.	T.	Very good	Sept.	Spreading	Enormous bearer.
(2) *Bush.*						
Early Prolific ..	K.	—	Good	July	Bush	Great bearer.
Kirke's Blue ..	—	T.	Rich and juicy	Sept.	Pyramid	Large plums.
Greengage	—	T.	Very rich	Aug.	Bush	Vigorous grower.

Variety.	Use. Kitchen.	Use. Table.	Comparative Quality.	Time when used.	Habit.	General Remarks.
CHERRIES. (1) *Standard.*						
Bedford Prolific ..	—	T.	Large, black, good	July	Pyramid	Hardy.
Frogmore Bigarreau	—	T.	Yellowish-red; very good	Middle of June	—	Great bearer.
Bigarreau Napoleon	—	T.	Large, red, rich, and tender	July to Aug.	—	Great bearer.
Bigarreau Kentish	—	T.	Large, yellowish-red	Late in July	—	Good bearer.
Governor Wood ..	—	T.	Large, light-red, good	Early in July	—	Vigorous grower.
(2) *Bush.*						
Archduke	—	T.	Dark-red, good	July		
Empress Eugénie ..	—	T.	Red, large, good	End of July	Pyramid	
May Duke	—	T.	Red, large, very good	July	Pyramid	
Morello	—	T.	Dark-red or black, large	Aug. to Sept.	Pyramid	Good producer.
Kentish	K.	—	Red, medium size	July		
GOOSEBERRIES.						
Lancashire Lad ..	—	—	Bright red, large	—	Upright	Good bearer.
Crown Bob	—	—	Red, large, good quality	—	—	Good bearer
Warrington	—	—	Very good for preserves	—	Drooping	Great bearer.
Whitesmith	—	—	White	—	—	Large, fine bush.
Whinham's Industry	—	—	Dull red, thick skin	—	—	Very great bearer, often pulled green.
RASPBERRIES.						
Carter's Prolific ..	—	—	Dull red, large and fine	—	—	Very great bearer.
Fastolff	—	—	Medium; bright red	—	—	Hardy grower.
BLACK CURRANTS.						
Black Naples ..	—	—	Large, good	—	—	
Lee's Prolific ..	—	—	Fine and large, rich, sweet	—	—	The best kind of black currant.
RED CURRANTS.						
Haughton Castle ..	—	—	Large bunches	—	—	Fair bearer, sturdy grower.
La Versailles ..	—	—	Very large	—	—	Moderate grower.
WHITE CURRANTS.						
White Dutch ..	—	—	Large and fine	—	—	Good bush.
White Grape ..	—	—	Large, very good			

Variety.	Use.		Comparative Quality.	Time when used.	Habit.	General Remarks.
	Kitchen.	Table.				
STRAWBERRIES.						
Elton Pine	—	—	Finely coloured	—	—	Good for preserving.
Laxton's Noble ..	—	—	Large and fine	—	—	Early, vigorous grower; not suitable for light land.
Sir Charles Napier..	—	—	Fine, large	—	—	Late, abundant producer.
Sir Joseph Paxton ..	—	—	Very rich	—	—	Heavy cropper; packs well.
Vicomtesse Hericart de Thury	—	—	Fine and large	—	—	Good for preserving: stands wet weather well.

Planting.—Before planting, a sketch should be made of the ground, and the position for each tree exactly determined. The trees should always be in rows, running north and south if possible, thus getting the maximum amount of sunshine for the fruit. Then mark the lines carefully, seeing that they are parallel, and determine the position for the standards first. The distances apart of the fruit-trees are given below.

Standard apples, pears, or plums, 24 feet. This allows bush trees to grow below. On poor ground the branches will not spread so much, and they may be grown 18 feet apart, with gooseberries or currants below.

Cherries, on good ground, 30 feet; on poorer ground, 24 feet.

Bush trees, beneath the standards, may be 6 to 8 feet apart. The former distance does well enough for a few years, but when the standards grow extensively, every alternate one should be removed.

Gooseberries and currants, 5 or 6 feet apart when among other trees.

Raspberries, 4 or 5 feet between rows, 12 to 15 inches in rows.

Strawberries are planted alone, in lines 30 inches apart, with 15 to 20 inches in the rows.

In planting, dig a wide and fairly shallow hole first. Then drive in the stake in the middle. These should be at least seven feet long for standards, and be firmly fixed. Now carefully plant the tree, laying out the roots to their full length, cutting off coarse roots, and trimming any that may have been cut with the spade in getting out. In cutting, always perform the operation from below, so that the open surface rests more thoroughly on the soil. Next

gently add some very fine good soil, until the roots are thoroughly covered, pressing it down firmly. Add a little manure, and heap on the soil until it reaches the mark at which it formerly stood in the nursery. Never dig a deep hole in the ground and press the tree down into it. The roots are all turned toward the surface, and the close proximity to the subsoil is often injurious. In heavy soils, if a hole is dug into the solid clay, it collects water, and this soon causes the roots of the plants to rot.

After planting the standards, the bush fruit of the same kind and then the gooseberries and currants are put in in a similar manner. Each tree should then be carefully labelled, in order that it may be easily recognized.

Planting is usually begun in autumn and continued through winter.

Strawberries are not generally grown beneath any of the fruit-trees. The land must be well broken up, cleaned, and manured heavily with farmyard manure. Plant either early in August or in March. If done late in autumn, they are liable to be thrown out of the ground by frost. A hole is simply made at the top of the ridge with a dibbling stick. Press in the plant firmly, and return a little of the soil, keeping the crown clear. Runners are soon thrown out in the spring, and these are usually all cut off the first summer. Keep the land very clean, and in next spring, when the plant begins to bloom, lay clean long straw between the ridges to prevent the fruit getting dirty. After picking the fruit, clear off the straw and apply more manure. Cut off any long unnecessary shoots, and after six years the plants themselves should be taken out, as by that time they will be spent.

After Cultivation of Fruit Trees.—When the standards are planted on arable land it is best to keep the land very clean, and, after a few years, lay it down to grass. This grass should not be left to be cut for hay, as the long grass shades the ground, and allows less sunshine and air to get about the roots. It is far better to feed it off with sheep, and, by giving the animals cake or corn, valuable manure is left behind. For mixed plantations, the land must be kept clear of weeds, and this has frequently to be done by manual labour.

Pruning.—This, of course, depends largely on the age of the plant. For standard apples it is well to cut back the branches to within one-third the distance from the stem. If the tree is very young, and the ground not so rich, prune very little, but leave till next year. In the second year only about one-half of the young growth of the leading branches are cut off, the centre of the tree being kept well open by cutting out surplus wood. Do not prune very hard after four or five years, remembering

that it is only necessary to keep the tree open to sunshine and air.

Standard pears and plums are pruned in a similar manner to apples. Cherries require only to be pruned sparingly for the first two years, and, after that, need very little application of the knife.

Bush apples, especially when of weak growth, need a lot of cutting back. The centre must be well opened, and many of the leading branches should be cut back two-thirds of their length to a terminal bud. When about five feet high, the leading shoots need close cutting, so as to keep them from getting too high. Their shape also must be constantly thought of.

Bush pears need less pruning. Soon after planting, the shoots (about six in number) should be cut back to within one foot from the trunk. The next year, shorten the leading branches, and cut out any superfluous ones. Little is now required until the tree gets to its proper height. Then shorten as before.

Gooseberries should have a considerable number of their shoots cut off, and the rest shortened, during the first year. Shorten the side growths nearly to the main stem. The centre needs to be kept well open to allow the fruit to be easily plucked. Always prune so as to keep the branches as upright as possible, and pluck most of the fruit when green for the first season or two, and thus prevent exhaustion.

After planting raspberries, shorten to within a foot of the ground. Cut away all canes that have finished producing fruit in autumn, and in winter cut down the young canes and shorten the rest considerably.

Red and white currants are treated similarly to gooseberries. They need to be much more open, and useless side growths should be cleared off early in summer. During winter most branches will need about one-half of their length to be cut away.

Black currants do not require so much pruning. Cut off any poor shoots, or old branches, and allow a good growth of young shoots.

Pruning should be done, if possible, about February; but where the orchards are extensive, it may be commenced in autumn and continued through winter, beginning with the most hardy and oldest kinds.

The operation is usually done by means of hand pruning-shears, but there are often some branches difficult to reach. To meet these cases, elongated pruning appliances have been made, the cutting apparatus being on the end of a long pole and moved by a cord.

Gathering Fruit.—Apples or other kinds of fruit should not

be knocked off the trees with poles or shaken off. In both cases the fruit is bruised, and will not keep. Early varieties should be gathered as soon as possible, when not quite ripe, and stored a few days. Late kinds are allowed to remain till fully ripe, as they then keep much better. Cider apples are picked up as they fall, and the remainder knocked off with poles about the third week in September.

In gathering, use a tall step-ladder, and carefully gather the fruit into bags. Small baskets will do quite as well. Keep each variety of fruit by itself, picking out all bruised or small inferior ones. The rest are then graded according to their size and appearance.

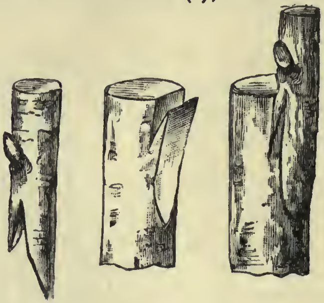
Sending to Market.—Fruit should always be sent to market in a tidy, attractive form. Apples are made into "sieves" or "half sieves." The best dessert pears are packed in single rows in shallow boxes, with some soft material at the bottom and top, and also a little between the fruit. Very fine fruit is sometimes wrapped individually in tissue paper. Wood wool is very good for packing fruit amongst. Gooseberries and other soft fruit need to be gathered as soon as ripe. The best specimens are packed neatly in punnets or in small square chip baskets. The poorer kinds are packed in larger receptacles, such as peck baskets, and generally sent to some jam factory.

Always despatch the fruit in as fresh a condition as possible, after having decided which market will pay best. By grading the fruit a much better price is often obtained.

Storing Fruit.—Apples are best preserved at a low temperature, in a somewhat moist atmosphere. A barn may easily be converted into a good apple-store, by putting a wooden wall all around, about a foot from the other, and filling up the space between them with sawdust. The room should be well ventilated, and fitted with shelves about three feet wide and one foot apart. Pears need a drier and warmer room than apples, and require more space. The temperature may easily be raised to the proper pitch by hot-water pipes. In both cases the fruit should be handled as little as possible, and, after the room has been emptied, it should be well washed out, a coat of whitewash given to the walls and roof, and fumigated with burning sulphur.

Grafting and Budding.—In order to get the fruit as early as possible, pieces of the required tree are usually grafted upon some suitable stock. The stocks themselves are raised from seed or cuttings. In autumn, when large enough, they are lifted out, their roots trimmed, and then planted in rows about three feet apart. By August they are fit for budding, or for grafting in spring. They are cut down to within six inches from the ground. The

scions to be grafted are cut in February, and put in the ground for some time to stop the flow of sap. In March or April the operation is completed. Make a clean sloping cut just below a bud. Then nick a piece out of the cut end (Fig. 98, *a*), and make similar cuts on the stock (*b*), and fit the two together (*c*).

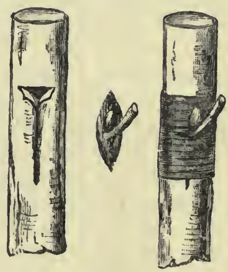


a *b* *c*

FIG. 98.—Grafting. *a*, the scion; *b*, the stock; *c*, the completed operation.

Then bind up with a little bass matting, and cover over the wound with a mixture of plastic clay, cows' dung, and finely chopped hay.

In "approach grafting" the stock is left to grow longer, and a piece is cut as deep as the Cambium Layer, nearer the ground. A similar piece is cut out of the scion, and the two parts bound



a *b* *c*

FIG. 99.—Budding. *a*, the stock; *b*, the bud; *c*, the completed operation.

together as before. The end of the scion should be kept in a pot of earth.

In "cleft grafting" a cut is made in the crown of the stock, and the wedge-shaped end of the shoot inserted. Then bind round and plaster over.

"Budding" (Fig. 99) is performed in August. In this case the

stock is not cut down. A branch is cut from the tree it is intended to propagate, and placed in water for a short while. The leaves are then cut off, and then the buds from about the middle of the branch taken. This is a delicate operation, and requires considerable skill. With a sharp knife, cut rather deeply into the wood a little above the bud, and come out with a long gradual slope below. Now carefully lift out the wood from the small piece of bark. Make a T-shaped cut in the bark of the stock, and raise the edges. Insert the bud in the cut in a natural position, and bind around with bass.

Old Orchards.—Sometimes a farmer may enter a steading on which is an old orchard, capable of paying for improvement. One of the first things is to cut out all superfluous branches. When cutting a large bough, the saw is needed, and a small cut should first be made on the underside to prevent the bark being torn through the falling of the branch. In order to get rid of lichens and moss, dress the trees with hot lime, slightly slaked. All loose bark should be scraped off. For about eight feet around the tree it is often advisable to dig up the surface for a few inches. A little soot put in with other manures does great good.

Fairly young trees may be found with a tendency to form wood rather than fruit. In this case open up the soil, cut off any coarse roots, and sever the tap root. Put fresh soil around the trunk. This is called "root pruning," and acts very beneficially by increasing the number of rootlets.

CHAPTER XI.

METEOROLOGY.

As farming, especially with regard to crops, depends so much upon the weather, a few remarks upon the subject of meteorology will not be out of place. The name is derived from the Greek, meaning the science of the atmosphere.

Temperature needs special attention, because it is partly on account of the differences in it that so much variation in the productive powers of soils exists. As a rule, the mean temperature will be found to get less the farther the observer is from the equator. It is said to decrease at the rate of 1° F. for 111 miles. Were the earth perfectly regular in form, the temperature of any place might be easily calculated; but there are many causes which modify the climate. After latitude comes longitude. The western coasts of the British Isles are warmer than the corresponding parts on the east side. The reason for this is easily seen. The west coasts are more or less washed by the warm Gulf stream, while the east is exposed to the dry, cold winds sweeping over the Continent. According to Lloyd, the temperature decreases from the west to the east at the rate of 1° F. for every sixty miles.

Altitude has much the same effect as latitude, and, as a rule, the temperature is lowered 1° F. for every elevation of 300 feet. From this we see that an increased height of 300 feet reduces the temperature quite as much as an advance of 111 miles towards the pole. Wheat will not ripen in this country at greater elevations than 1200 feet, and at 1500 feet our hardiest cereal crops are affected in their growth.

The proximity to large bodies of water (as the sea, lakes, and rivers) have their effect upon the climate. The first-named will exert a favourable influence. The sea is not so readily affected by heat and cold as the land, consequently a greater uniformity is

preserved, the summers being relatively cooler and the winters warmer than at inland places. Lakes, rivers, and marshes do not always give such good results. They may be the cause of fogs, referred to later on.

The colour and texture of the soil influence the climate. Dark soils absorb heat best, but they also give it up rapidly. White soils are slow to rise in temperature, and hence we see why chalky land is usually cool. Sand rapidly takes in heat, and also is very retentive; after it, with regard to the latter power, comes clay, and then humus. Clays are usually of a cold nature, and often cause fogs.

Aspect and slope also need to be taken into consideration.

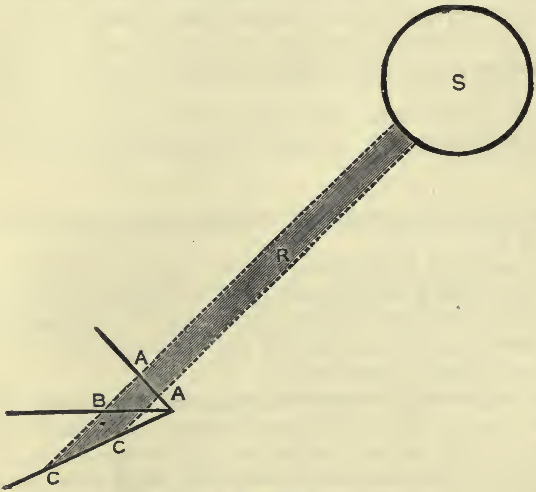


FIG. 100.—Slope as affecting temperature.

For farm crops a south or south-west aspect is almost always the best. For a dairy the north side of the steading should be chosen, as it is generally the coolest. Pastures facing the north are more liable to be overrun by moss than any others. In England it has been found that land facing the south and inclined at an angle of 25° to 30° receives the maximum amount of heat. The slope influences the question by exposing a larger or smaller amount of surface to the same amount of light.

The above diagram (Fig. 100) will illustrate this. R represents numerous rays of light from the sun S, falling upon three differently inclined planes. AA, BB, and CC represent respectively the spaces which would be covered in each case. The same amount

of heat is received by A A as by CC, and, as the former space is the least, there will be more heat per square inch.

Shelter also affects the climate of districts. When absent naturally, it may often be provided by planting belts of trees. Mountain-chains may either keep off cold or hot winds, according to their position. On exposed positions snow will be found to lie longest, and the fiercest blasts will be met with there.

Of the months of the year, January is found to be, on an average, the coldest, and July the warmest. The following table, showing the temperatures of each month, was compiled at Greenwich, and is the average of over forty years.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Mean temperature in shade	38·4	39·5	41·6	46·0	52·5	58·9	62·3	56·5	57·0	49·9	43·4	39·8
Daily range of temperature	9·5	11·1	14·7	18·4	20·4	21·0	21·0	19·9	18·2	14·5	11·4	9·3

From this the average temperature throughout the year would be 48·8° F.

The warmest hour of the day is 2 p.m.; the coldest, 4 a.m. It has been found that the average temperature of the day may be found fairly correctly by taking the means at 9 a.m. and p.m.

Pressure.—A description of the barometer has been given in the "Agricultural Engineering."

The height of the barometer varies extremely little in travelling from south to north. The mean pressure is about 29·87 inches; it ranges from 29·808 inches at Nairn to 29·965 inches at Plymouth. The barometer is, however, found to fall considerably according to its elevation, and hence all results should be reduced to the sea-level. This peculiarity has been made use of in determining the heights of mountains, etc. The differences between the barometrical readings at the nearest point on the sea-level and the other place are taken in hundredths of inches. This multiplied by nine gives the difference in height between the two points in feet. Thus, say the reading of the barometer was 28·8 inches at an elevated situation, when it was 29·85 inches at the sea-level, then $1·05 \times 100 \times 9 = 945$ feet as the difference between the two heights. For this work, the aneroid barometer is most convenient.

It is found that the pressure varies regularly to a slight extent according to the hour of the day. The barometer is highest about 9 a.m. and 9 p.m., and lowest at 3 a.m. and 3 p.m. For the

months of the year, it is highest in May or June, and records the smallest pressures in October and November.

A curious law with regard to pressure is that, if you stand with your back to the wind, the barometer will be lower at places on your left than on your right.

Rain.—Upon this important subject depends to a great extent the subject of drainage.

A fall of rain is caused by the cooling of some cloud saturated with moisture. As the temperature is lowered, the capacity of the air for holding water vapour diminishes. The surplus moisture condenses, forming drops which descend as rain.

We find the rainfall varies very much. Some years are considerably drier than others, and at Greenwich a variation of eighteen or nineteen inches has been experienced between two years. The amount of rain is usually between twenty-five and thirty inches.

The rainfall also varies according to the month. The least amount falls in February and March, the most in July and October.

AVERAGE RAINFALL, IN INCHES, PER MONTH.

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1·89	1·57	1·52	1·74	1·98	1·96	2·50	2·35	2·43	2·76	2·36	1·99

From these figures, we see that 20 per cent. of the rain falls in spring, 23 per cent. in summer, 31 per cent. in autumn, and 26 per cent. in winter.

The amount of rain is found to vary considerably according to the longitude, the east side being considerably the drier. As stated before, the west coast is washed by the Gulf Stream. This is a large current of warm water, originating near the equator. It passes through the Gulf of Mexico, and then crosses the Atlantic in a north-easterly direction, conferring a certain degree of warmth upon many places. The winds sweeping across the Atlantic become charged with moisture, and are also of a fairly high temperature. On striking the western coasts they are cooled, and rains result. Ireland receives the first showers, and the highlands of the Lake district and Cornwall also cause a plentiful deposition. As the wind passes across the island, it gradually loses its moisture, and is able to deposit very little on the east side. Again, the east winds have swept over vast tracts of land in Asia and Europe, and have had little chance of taking up

water vapour. Hence the chief causes of difference between the warm, moist, westerly winds, and the cold dry blasts from the east. The climate of the latter is more suited for corn-growing, and the former for stock-rearing.

The differences between the rainfalls of the two parts are seen in the following table:—

East.	inches.	*West.*	inches.
Greenwich	26	Penzance, Cornwall	45
Norwich	27	Gloucester	$31\frac{1}{2}$
Lincoln	24	Llandudno	$33\frac{1}{2}$
North Shields	27	Lancaster	$40\frac{1}{2}$
Edinburgh	$28\frac{1}{2}$	Glasgow	43
Average	$26\frac{1}{2}$	Average	$38\frac{1}{2}$

The north-west is, on an average, rainier than the south-west. The rainfall in the north-west may be taken as 38 inches; in the south-west 34 inches; in the centre 28; in the east 26 inches.

Local circumstances greatly influence the amount of rain. As a rule, hilly districts, by condensing the clouds, have more showers than flat land. Seathwaite in Cumberland is the rainiest place in England; $224\frac{1}{2}$ inches have been recorded there in a year.

The determination of the amount of rain needs to be taken in every district. The operation is fairly simple. The apparatus needed consists of a funnel, either five or eight inches wide, fitted into a copper can below. In order that snow may be retained a vertical cylinder is placed on the top. This rain-gauge is placed in an exposed position, the top being perfectly level and one foot from the ground. At a fixed time each day, the water is emptied out of the can into a cylindrical measuring glass. This may have an area at the end of one square inch, and is graduated so that the amount of rain is easily seen. Of course, as the funnel has a much wider area than this, the number of inches must be reduced proportionately.

A gallon of water weighs ten pounds, and, if the rainfall were one inch, this amount would be collected on two square feet. An inch of rain according to this would be equal to $97\frac{1}{2}$ tons, or roughly 100 tons per acre, or about 60,000 tons per square mile.

Snow consists of frozen aqueous vapour. It is readily seen to be made up of beautiful hexagonal crystals. Snow can be measured by the rain gauge, care being taken that the apparatus

is properly exposed, and not in a place where drifts are likely to occur. Roughly, one foot of snow equals one inch rain. When a large amount is collected in the gauge, it may be thawed by adding a measured amount of hot water.

Hail consists of frozen drops of rain; many of the little hailstones thus produced congeal together to form larger ones. Hailstorms are most frequent in summer, the amount which falls may be measured in the same way as rain.

Dew is the precipitation of moisture without any visible cloud, indeed it takes place best on nights when the sky is perfectly clear. On those nights on which the conditions are favourable, the amount of heat radiated from the earth is greater than that received from the atmosphere. The consequence of this lowering of temperature is that the lower layers of air are chilled, and deposit the water vapour they contain. As this moisture has not far to travel, it does not have time to form into large drops. The point at which dew begins to separate is termed the dew-point. It is not fixed, but varies according to circumstances. Clouds, by reflecting back the radiated heat of the earth, oppose the formation of dew; and winds, by carrying away the moisture, prevent its deposition. As the air comparatively contains most water vapour in summer, most dew falls then.

The annual amount of dew deposited may be taken as under 1·5 inches. If the dew-point be under 32° F., hoar-frost is formed.

Fogs are caused by the sudden cooling of warm damp bodies of air. This may occur through such a current meeting a colder one, or by passing over a cold surface, as a bed of clay or an iceberg, or by the sudden chilling of saturated air over a flowing stream. Again, when dew is forming, the lower strata of air may be left saturated with a reduced temperature. This, by mixing with warmer layers above, may cause a fog. Again, a cold current may give a like result by flowing down into some hollow or valley already filled with warm moist air.

Mists are similar to fogs, but the particles of vapour are of larger size. *Clouds* are really elevated mists or fogs.

Wind.—On the direction of the wind we have seen that the rainfall depends to a certain extent. The average directions for the year, taken at Greenwich, are as follows: from the S.W. 104 days, N.E. 48 days, N. 41 days, W. 38 days, S. 34 days, N.W. 24 days, E. 22 days, S.E. 20 days, calm 34 days. Total, 365 days.

The velocities of various winds are given below:—

Miles per Hour.	Pressure in Pounds on a Square Foot.	Description.
1	0·005	Hardly perceptible.
2	0·020	Just perceptible.
3	0·045	
4	0·080	Light breeze.
5	0·125	
6	0·180	Gentle pleasant wind.
7	0·320	
10	0·500	Pleasant, brisk wind.
15	1·125	
20	2·000	Very brisk.
25	3·125	
30	4·500	Strong, high wind.
35	6·125	
40	8·000	Very high.
45	10·125	
50	12·500	Storm.
60	18·000	Great storm.
80	32·000	Hurricane.
100	50·000	Tornado sweeping off buildings.

The Relation between Sunspots and the Weather.—When viewing the sun through a telescope, certain spots are visible upon its surface. These spots vary in position, size, and form, and are not fixed. They are found to be most numerous at intervals of between ten and eleven years, and also have points of a fairly regular character when very few are to be seen. These dark spots, by extending over a greater or less space on the sun's surface, to a certain extent limit the amount of heat the earth receives. The rainfall, storms, etc., are affected, and some relation between these periods and years of famine have been traced. The subject is, however, by no means fully worked out.

CHAPTER XII.

AGRICULTURAL EXPERIMENTS.

THE practice of agriculture is really founded upon experiments, extending usually over long periods. For instance, when turnips were first introduced they were grown only by a few farmers, but, being found to answer well, their cultivation gradually extended, until now there are comparatively few farmers who have not some of their land under this crop. What is this but an experiment on a large scale?

Experiments, as conducted now, take in much more of the science of agriculture, and many important results are at present being obtained. The two most important experimental stations are Rothamsted, in Hertfordshire, conducted by Sir J. B. Lawes and Dr. Gilbert; Woburn, belonging to the Duke of Bedford, and superintended partly by Dr. Voelcker. Agricultural experiments are carried on also by the Bath and West of England Society, and a large number of County Councils have taken the matter up. In the future, we may possibly see an experimental station in every county. An entire farm is not needed for the purpose; a fairly large field will often be quite sufficient.

In an experiment of any kind, the greatest care must be taken to secure a correct result. Comparisons can only be fairly made when the experiments have been carried out under similar conditions. Thus, for instance, should the effect of a certain manure be tested upon, say, wheat in a dry year, the results obtained with another manure upon wheat in the next season would not allow the value of the two to be accurately compared.

Experiments with Live Stock.—So numerous are the experiments, not only with live stock, but with crops, that we can do very little more than indicate them.

Beginning with foods, Lawes and Gilbert have worked out

their comparative digestibilities with horses, cattle, sheep, and pigs. Then comes their value to cattle, as regards their flesh-forming or milk-producing qualities. These points may be worked out by the farmer for his own satisfaction, but they have already been very thoroughly done for him. The plan was to select, say, two lots of four bullocks, and house them in a similar way in two boxes, byres, or yards. Then the different foods were given, the progress of the beasts noticed, and the weight of beef produced at the end. With the dairy cows, the quality, as well as quantity, of milk must be noticed. The flavour of the produce is almost as important as the amount. Experiments as to feeding in open and covered yards, and other particulars may be worked out. Sheep and pigs may, in like manner, be dealt with.

In performing these experiments, it must be remembered that the different lots of animals must be as even as possible, and perfectly healthy. If one be only slightly affected with some complaint, it might not lay on flesh as it ought to do, and perhaps favour the opinion that the food was not so good as that which the other lots received.

Many experiments cannot be undertaken by the ordinary farmer. For instance, few could work out such a subject as the manurial value of food. In the ordinary practice of farming, however, many of the feeding experiments, just mentioned, may be carried out. Again, the most profitable breeds of cattle, sheep, or pigs can well be found out. In such experiments as these, regard must be paid to the prices of food stuffs, etc.

Experiments with Crops.—These are much more numerous than the preceding class, taking in, as they do, the wide subject of manuring. The feeding of live stock gives fairly uniform results, but crops vary greatly according to the soil on which they are grown. The results obtained at Rothamsted and Woburn, though of very great general value, might yet not be applicable in every case, on account of local circumstances. This points to the farmer conducting small experiments for himself. The soil at Rothamsted is a heavy loam, resting on a stiff clay subsoil, which overlies the chalk. It is suited for wheat, but not very well for turnips or barley. At Woburn the soil consists of a deep, sandy loam, with a sandy subsoil.

Before commencing any experiments, a field of uniform character should be selected. It is thoroughly tilled, and then divided out into rectangular plots. These are, at Woburn, one-sixth to one-fourth of an acre each in area, but plots less than this can be used. The minimum area is one-twentieth of an acre each; on smaller pieces a slight irregularity as to the amount of plant-food present may greatly affect the results, when calculated out to so much yield

per acre. The corners of the plots should be marked in a permanent manner, and a path about two feet wide should go around each piece, so as to cut it off.

If possible, the experiments in each subject should be conducted for more than one season. Some at Rothamsted have now gone on for more than forty years.

It is not often advisable to attempt any complicated experiments; a few simple ones, bearing directly upon the subject, are of more practical use.

Taking cereal crops to commence with, we must first consider what the plants stand most in need of, *i.e.* nitrogen. This may be taken for granted, as it has been so often proved. A plot is first sown which has not been manured for a considerable time previously; this serves as a standard for comparison. The next plot receives farmyard manure, say at the rate of twelve tons per acre. The effects of artificial dressings must now be observed. To one piece give, say, 275 lbs. nitrate of soda, and to another 200 lbs. ammonia salts, so made up that both contain the same amount of nitrogen. Another plot may get nitrogenous and mineral manures (say 2 cwts. superphosphate, and 1 cwt. kainit). Other experiments, as to the quantities giving best results, may be undertaken, if there be enough space. Barley and oats may be taken under similar conditions to wheat. In harvesting, the plots should be cut at the same time, and dried, and stacked in a similar manner. On thrashing, the yields, in bushels of grain, and its weight, and the amount of straw, should be carefully noticed. It is almost needless to say that the produce of each plot must be kept by itself, not only in cutting, but also in stacking and thrashing. The results should be carefully recorded.

Another part of the field may be set apart for root crops. Turnips or swedes will usually occupy the most prominent position. The first plot receives no manure; the second, say, 15 tons farmyard manure; the third, 3 cwts. superphosphate; the fourth has 1 cwt. nitrate of soda in addition. Another may get farmyard manure with superphosphate and nitrate of soda. A plot similar to No. 4 may receive a dressing of potash salts. The value of guano, or of dissolved bones over superphosphate, may be tried, if needed.

Mangels will not be treated exactly the same as turnips. Nitrogenous dressings are here of greater benefit, and common salt may be used in the experiments. The amounts of manures given will be greater than with the last crop.

Experiments with potatoes are not quite so common. One or two plots will receive potassic dressings with or without phosphates and nitrogenous manures.

Fodder crops have not received so much attention. With clover it will be found that nitrate of soda or ammonium sulphate alone do not give very good results. Superphosphate is much better, and potash salts also have good effects. With grasses, the nitrogenous dressings give the greatest crops, and hence, on pastures, when grasses and clovers mix, numerous experiments may be carried out as to the relative amounts of nitrogenous and phosphatic manures in mixtures which will pay best. Again, the kind of phosphatic material may need determining. Will superphosphate, dissolved bones, ground bones, or basic slag be of most use? These questions should be worked out, if possible.

For information as to the results of these and other experiments, we would refer the student to numerous papers by Sir J. B. Lawes and Sir J. H. Gilbert, and also by Dr. Voelcker, in the *Journals of the Royal Agricultural Society*, and also to those by Dr. Aitken, Mr. John Speir, Mr. John Milne, and others, in the *Transactions of the Highland and Agricultural Society*.

QUESTIONS SET AT THE SCIENCE AND ART EXAMINATIONS IN AGRICULTURE.

1891.

Advanced Stage.

Six questions to be answered.

21. How would you classify soils by the chemical constituents they contain, and by their physical value? How do these influence their agricultural value?

22. Describe the food necessary for the growth of cultivated crops, the sources of supply, and the condition in which plants receive their nourishment.

23. Explain the influence of soil and climate upon the degree of perfection obtainable in a plant's growth.

24. Explain the principles regulating the selection and economic use of artificial manures.

25. State what materials are used for returning to the soil the mineral matter removed from it by the bones of animals reared upon it? How are these materials prepared for their most economical use?

26. Give a course of cropping suitable for heavy land, and another course for light soils. Show the relative advantages of each course, and state your reasons for considering them suitable for these soils respectively.

27. Describe the practice of "bare-fallowing." Explain the reasons which have led to the growth of root-crops instead of bare fallows, and any advantage so gained.

28. How would the system of husbandry most desirable for a farm be influenced by the character of its soil and climate?

29. What changes take place in the malting of barley? What are the relative merits of barley and malt for feeding purposes? and how should they be used?

30. What circumstances influence the quality and quantity of the milk of cows? and how may the duration of the flow be influenced?

31. How do soil and climate influence the quality of apples for table use, and for the manufacture of cider?

32. What are the causes of butter becoming rancid and acquiring a bad flavour? and how may these be prevented?

33. What are the qualities we seek to attain in breeding poultry for table use? and how are these best secured?

34. Do bees increase our fruit crops? If so, how is this result accomplished?

1892.

Advanced Stage.

21. What are the effects of a top dressing of nitrate of soda upon a growing crop of wheat? and what are the effects upon the soil?

22. Why should nitrate of soda be applied in spring? In what quantity is it usually applied per acre?

23. Why is the nitrogen contained in farmyard manure slower and more permanent in its action than the nitrogen contained in nitrate of soda and ammonia salts?

24. Why does wheat generally yield well after a crop of red clover? and why does it not thrive so well after Italian ryegrass?

25. Give rotations suitable for light and for heavy soils.

26. Under what circumstances ought lime to be applied to land? What descriptions of rocks may be used as sources of lime?

27. Why is it now thought desirable to harvest corn crops before they are dead or fully ripe? Why is barley treated differently from wheat or oats in this respect?

28. What are the relative values of fat, starch, sugar, and vegetable albumen as foods for stock? Name some of the principal commercial foods from which these substances are derived.

29. Under what circumstances would you recommend thick or abundant seeding? and under what circumstances would you apply less seed? What quantities of seed per acre would you consider thick or thin seeding in the case of wheat, oats, and barley?

30. Describe a good bee-hive. How are bees best fed in winter? and what are the proper seasons for feeding them?

31. How may early and abundant laying be secured in the poultry yard? What means would you use to secure the best results from sitting hens?

32. In what respects has the making of butter been improved during recent years as compared with the older methods?

1893.

Advanced Stage.

21. What are the indications which would enable you to distinguish between a fertile soil and one which is unproductive?

22. When lime has to be applied to the land, how would you determine whether it should be used as quick or caustic lime or in some milder form?

23. Describe the various forms of phosphates which are used as manure, and show how to select the best and most economical form for different classes of soil.

24. Give the rotation of crops in any district you are acquainted with; specify how each crop is disposed of, and suggest any desirable alterations.

25. Under what conditions of soil and climate are oats produced of the most nutritive character, and most abundantly?

26. Describe the process of hay-making, explaining the chemical changes which take place.

27. Select any breed, either of cattle or sheep, and show how these have been rendered most profitable for any one or more purposes.

28. Explain the cause of shelter being economical and beneficial for the production of meat and milk.

29. Describe the conditions which most fully favour the production of milk of the highest value, and state the general principles involved therein.

30. Explain the best system of dairy management in any district you may be acquainted with, pointing out its excellencies and deficiencies (if any).

31. Wherein does the Harding system of Cheddar cheesemaking differ from the Canadian system now taught and practised in the West of Scotland?

32. What pasture grasses and other plants are most desired by hill farmers in Scotland on their sheep grazings at different parts of the year?

33. Aberdeenshire, and the north-west of Scotland generally, has become celebrated for the growth of the turnip crop. Can you give any reasons for this other than the system of farming followed?

34. On what general principles does the successful growth of poultry depend?

35. What are the advantages we gain by keeping bees? and how are these best secured?

1894.

Advanced Stage.

21. What influence have sand, humus, and clay upon the tenacity or heaviness of a soil? If the soil is too heavy, how would you lighten it? If too light, how would you increase its tenacity?

22. What is the origin of the nitrogenous humic matter in soils? Under what circumstances will it increase? Under what circumstances will it diminish?

23. What are the advantages and disadvantages of a summer fallow? To what soils and climates is the practice most suitable?

24. Arrange ordinary farm crops in two classes—those containing much and those containing little nitrogen. Mention any differences in the source of the nitrogen of the crops you have named.

25. Describe briefly the process of malting barley, and state the principal changes which occur in the structure and composition of the grain.

26. What is the usual percentage of phosphoric acid in the manure known as basic cinder, or Thomas's slag? What conditions are necessary for its successful use? To what crops is it specially applicable?

27. Classify farm animals according to the dryness or wetness of their manure, and show how this influences the amount of litter required. Classify sawdust, straw, and peat-moss, according to their absorptive power as litter. Which of these litters contains most nitrogen?

28. Name the principal breeds of sheep in England and Scotland. Point out those suitable for particular climates and districts, and those especially remarkable for wool or mutton.

29. What general alterations—(1) in the quantity of food consumed per day, (2) in the daily gain in live weight, (3) in the quantity of food required to produce a fixed weight of increase—will occur while a pig is being fattened?

30. In what forms does nitrogen occur in foods? Name foods in which each of these forms a prominent constituent. Mention the nutritive value of these nitrogenous compounds to the animal.

31. Arrange the following breeds in order of the relative richness (butter contents) of their milk: Holstein, Jersey, Kerry, Shorthorn. Which is generally morning's or evening's milk? The first or last milk leaving the udder? Explain, if you can, the cause of the variations in richness last mentioned.

32. What are the mixtures usually employed for spraying fruit trees, in order to check the attacks of (1) fungi, and (2) insects?

33. Name the breeds of poultry most suitable for egg production. State how you would obtain the greatest productions of eggs in winter time.

1891.

Honours.

Six questions to be answered.

41. On what principle, and by what method, would you calculate the albuminoid ratio of a food? Give an example.

42. Why is it difficult to ascertain correctly the albuminoid ratio of turnips, swedes, or mangel?

43. Calculate the cost of maintaining a farm-horse for one year. Deduce from this calculation the cost per working-day, to the farmer, of maintaining a farm horse. In answering this question, you must include all incidental expenses, such as shoeing, saddlery, depreciation, risk, etc., as well as food.

44. Describe suitable mixtures of food (stating the weights of each ingredient) to be given daily to a fattening bullock of about a thousand pounds live weight, during the *early*, *middle*, and *later* stages of fattening.

45. Describe a good system of bringing up calves, from birth to weaning.

46. Mention and describe six breeds of British sheep.

47. What amount of capital per acre would be required to enter and work a tract of, say, five hundred acres of arable land, of average quality and medium strength? Mention the various headings into which the sum named would be divided, and the proportionate amount required under each heading.

48. Supply information on the following points connected with wheat cultivation, supposing the wheat to follow a root crop:—(1) Preparation of ground. (2) Best period for sowing. (3) Quantity of seed. (4) Treatment between sowing and harvesting. (5) Harvesting.

49. Why do pastures tend to improve with age? Show how pastures may be exhausted and rendered poor by dairying, and the raising of young stock. Point out the best methods of preventing these ill effects. Also say why the sale of butter would be less likely to exhaust land than the sale of milk.

50. Upon what natural laws is the value of pedigree in domesticated animals based? Explain their action.

51. In what respects do our improved races of cattle, sheep, and pigs differ from the original or unimproved races from which they were derived?

52. Describe the composition and properties of cows' milk.

53. Explain why the drainage of wet land is followed by an improvement in the health of both animals and plants.

54. How may rankness or coarseness (sourness) in pastures be best remedied?

1894.

Honours.

41. Describe the circumstances and conditions which favour the production of farm seeds possessing a healthy and vigorous character.

42. What hidden points of character exist in seed corn of which we have no external evidence, and which render a judicious "change of seed" desirable?

43. What are the conditions which influence the feeding value of hay? and how may these be best secured?

44. Describe the changes which take place in "root crops" during their ripening, pointing out the differences observable in their use by stock, as they are more or less matured.

45. What principles are involved in the management of a flock of sheep, when early maturity and a good fleece are required?

46. Describe the formation of milk, and indicate the conditions whereby the flow may be made more or less abundant.

47. How does the breathing of impure air in cow-houses which are badly ventilated influence the milk produced, and the products manufactured from such milk?

48. Select one of our established breeds of cattle or sheep, and show the principles involved—

(*a*) In the establishment of that breed.

(*b*) In securing their continued fertility and high quality.

49. Give an outline of the economy of bee-hives, tracing the development of the queens and workers respectively.

50. Describe the structure of an egg, pointing out the changes taking place during incubation, and the conditions which favour healthy growth.

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